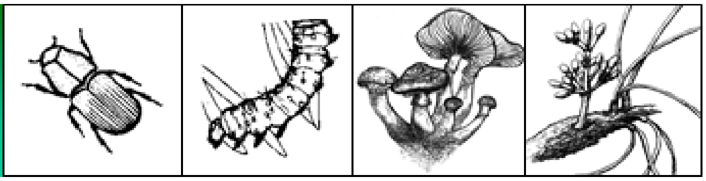
Forest Health Protection



19-08 ***September 2019***

Broad-level Reconstruction of Mountain Pine Beetle Spatial Extent and Impact throughout Montana and northern Idaho during the 1971–1989 Outbreak

Grant L. Harley[1], Joel M. Egan[2], Jessica L. Jenne[2], Jeffrey D. Kaiden[2], James H. McGee[1], and Rich Gibbs[1]

[1]Idaho Tree-Ring Lab, Department of Geography, University of Idaho, Moscow, Idaho
[2]State and Private Forestry, Forest Health Protection, Missoula, Montana

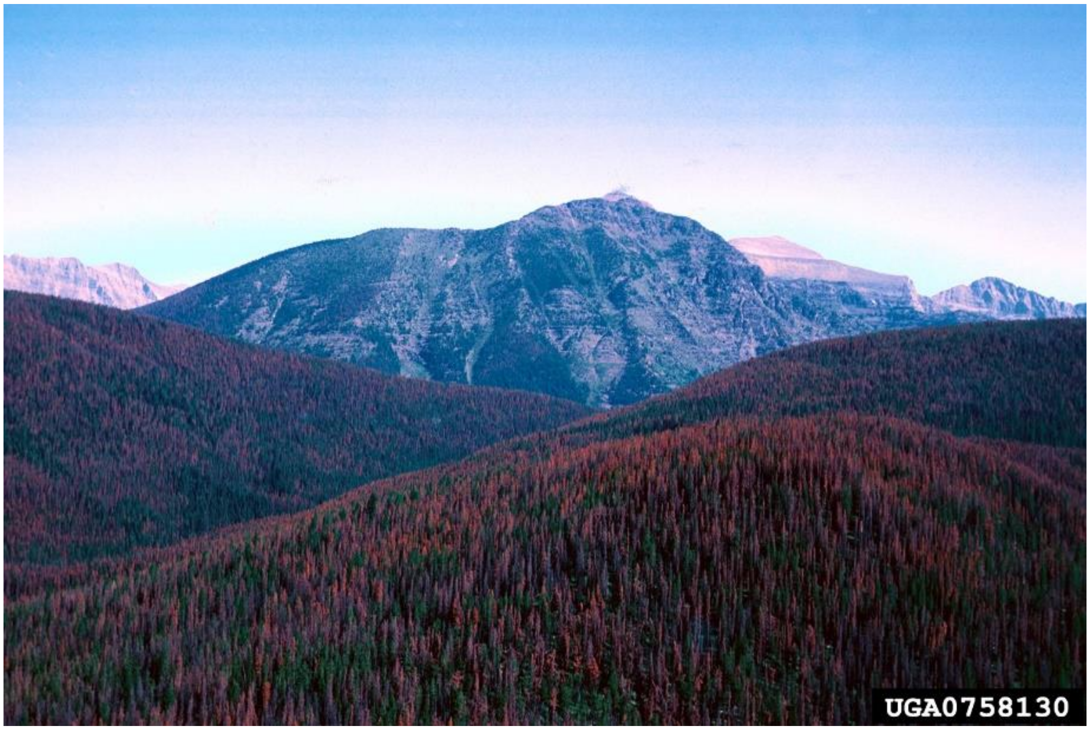


Figure 1. Photograph ©B. Ciesla showing severe and widespread mortality in lodgepole pine host caused by mountain pine beetles within Glacier National Park, USA.

United States Department of Agriculture | Forest Service | Northern Region | Region One
26 Fort Missoula Rd
Missoula, MT 59804-7203

Executive Summary

Mountain pine beetle (*Dendroctonus ponderosae* Hopkins, MPB) is a bark beetle native to western North America. During the period 1971–1989, a widespread infestation—hereafter referred to as the 1980s outbreak—occurred throughout susceptible pine forests across northern Idaho and Montana within the USDA Forest Service's Northern Region (R1). This report summarizes monitoring data from Forest Health Protection aerial detection surveys (ADS) to characterize the multi-temporal outbreak spatial extent, severity, pine host impacted, and drought factors associated with this outbreak period. The primary goal of this report is to provide an historical synthesis of the 1980s outbreak spatial extent, severity, yearly spread, and severity by species impacted.

Overall, 6,115,042 acres were mapped with MPB activity, of which contained 627,633 acres of aggregate, high severity impacted area. MPB activity was greatest within lodgepole pines, covering 4,887,627 acres (80% of total impacted area), with impacts also documented within whitebark/limber pines (5%), ponderosa pine (14%), and western white pines (1%). Palmer Drought Severity Index (PDSI) was associated both with outbreak initiation and with the individual 'boom' year in 1977 when MPB impacted area and severity increased 276% following severe between 1977 and 1978 aerial surveys. This 'boom year' occurred in conjunction with severe warm and cool season drought conditions (PDSI ranged from -2 to -4) that occurred from October 1976 – August 1977.

Introduction

Bark beetle infestations are an important and natural disturbance agent in pine forests of western North America (Taylor and Carrol 2004; Breshears et al. 2005). One of the most pervasive and prolific of the bark beetles, the mountain pine beetle (*Dendroctonus ponderosae* Hopkins;

MPB) is native to western North American and is an important disturbance agent that has co-evolved with pine (*Pinus* spp.) forests over many thousands of years (Brunelle et al. 2008). MPB has been shown to cause mortality in western white pine, whitebark pine (*Pinus albicaulis*), and limber pine (*Pinus flexis*) hosts in recent years, with severe and widespread damage documented across large tracts of contiguous forest complexes dominated by lodgepole pine (*Pinus contorta*) and/or ponderosa pine (*Pinus ponderosa*) hosts (Amman et al. 1990) (Figure 1,2).

Since the early 1900s, three severe and widespread MPB outbreaks are known to have occurred throughout R1. These include MPB outbreaks in the 1920s–1930s (Evenden 1945; Jenne and Egan, 2019), from 1971–1989; and from 1999–2015 (Egan et al., *in preparation*). Limited information about the 1980s MPB outbreak throughout R1 has been mentioned within scientific literature and documented in limited site-specific locations (Kulakowski et al. 2003; Lynch et al. 2006). However, to-date there has not been a holistic synopsis of the specific outbreak characteristics and pine hosts that were impacted during this time period. Such information is critical to summarize across a multi-year outbreak event scale, as well as across widespread pine forest ecosystems at a coarse spatial scale, in order to assess critical disturbance ecology monitoring to investigate if outbreak dynamics during the 1980s outbreak differed from prior or subsequent MPB outbreak events.

The goal of our assessment was to 1) reconstruct multi-year MPB outbreak characteristics from 1971-1989 across R1 with best-available monitoring data; 2) report outbreak attributes such as spatial extent, temporal dynamics, and species impacted during outbreak period; and 3) conduct analysis of association between outbreak occurrence and environmental drought conditions. Specifically, we 1) summarized the spatio-temporal progression of MPB impacts, with annual and multi-year cumulative infestations maps; 2) described the distribution of pine species impacted;

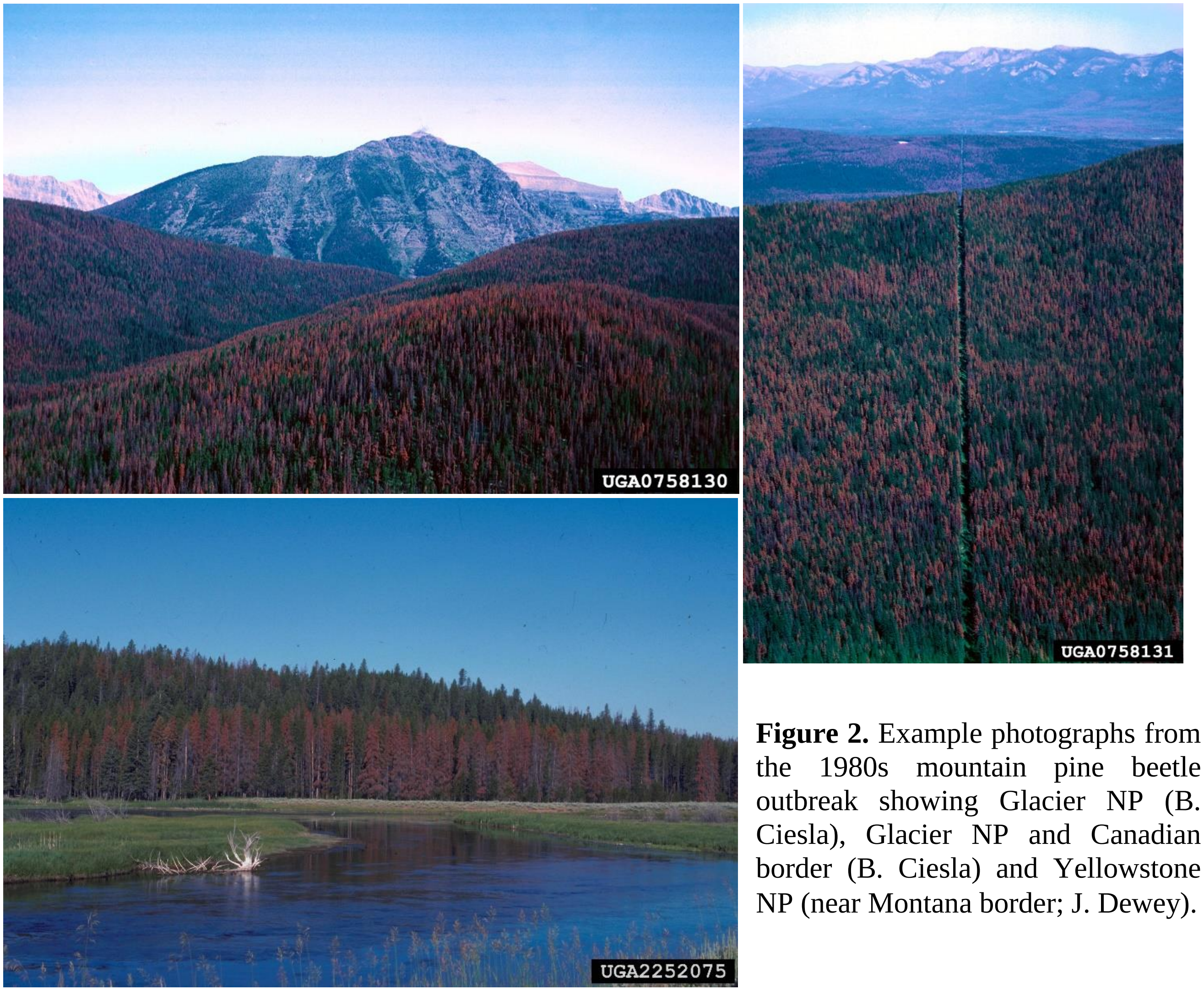


Figure 2. Example photographs from the 1980s mountain pine beetle outbreak showing Glacier NP (B. Ciesla), Glacier NP and Canadian border (B. Ciesla) and Yellowstone NP (near Montana border; J. Dewey).

and 3) identified associations between ambient drought conditions and MPB outbreak initiation and inter-year amplification.

Methods

Aerial survey data

Aerial survey data (ADS) were utilized to reconstruct the 1980s MPB outbreak event as no other sources of comprehensive forest health monitoring data, including remote sensing, were available as far back as 1971 when the outbreak initiated. Aerial survey data were collected each year during the 1980s outbreak (1971–1989) by USDA Forest Service, Forest Health Protection and partner agency staff (McConnell et al. 2000). These surveys were conducted annually to provide broad-scale information on forest pest damage occurrence, impact, and temporal trajectory. These data were collected through observational means rather than direct measurements, and thus have limitations (see Egan et al. 2019). While a limited number of quality control checks are conducted to ensure data meets nationally regulated quality standards, validation efforts are not sufficient to produce statistical accuracy and precision estimates for binary parameters (presence/absence) or to adjust continuous parameters (i.e. severity estimates) with standard error bounds.

Severity Class	**Trees/Ac mortality (TPA)**	**% mortality**	**% midpoint**

Low	< 10	< 10	5
Moderate	10–30	10–30	20
High	> 30	> 30	65

Few studies have attempted to validate aerial detection surveys (ADS) by assessing survey precision and accuracy. Johnson and Ross (2008) concluded that coarse-scale assessments using ADS data appear reasonable, while fine-scale analyses are inappropriate due to variable accuracies of damage location attributions. Damage severity estimates are often excluded from reporting due to estimation bias with ADS data estimates (Meddens et al. 2012; Backsen and Howell 2013). However, novel post-processing methods have been developed to reduce the influence of known sources of bias (Egan et al. 2019). These include collapsing continuous damage severity estimates recorded by surveyors into broad, qualitative impact classes (low, moderate, high) to reduce the importance of estimation bias while also presenting information classes relevant to land managers (Egan et al. 2014). This collapsing also categorizes data in a manner that can facilitate a cross-walk between different data collection variables (i.e. trees ac^{-1} vs. percent mortality) and differing forest health monitoring methods (i.e. aerial detection surveys vs. satellite-derived data). We attributed broad severity classes from continuous damage trees ac^{-1} estimates (Table 1).

Severity-weighted area

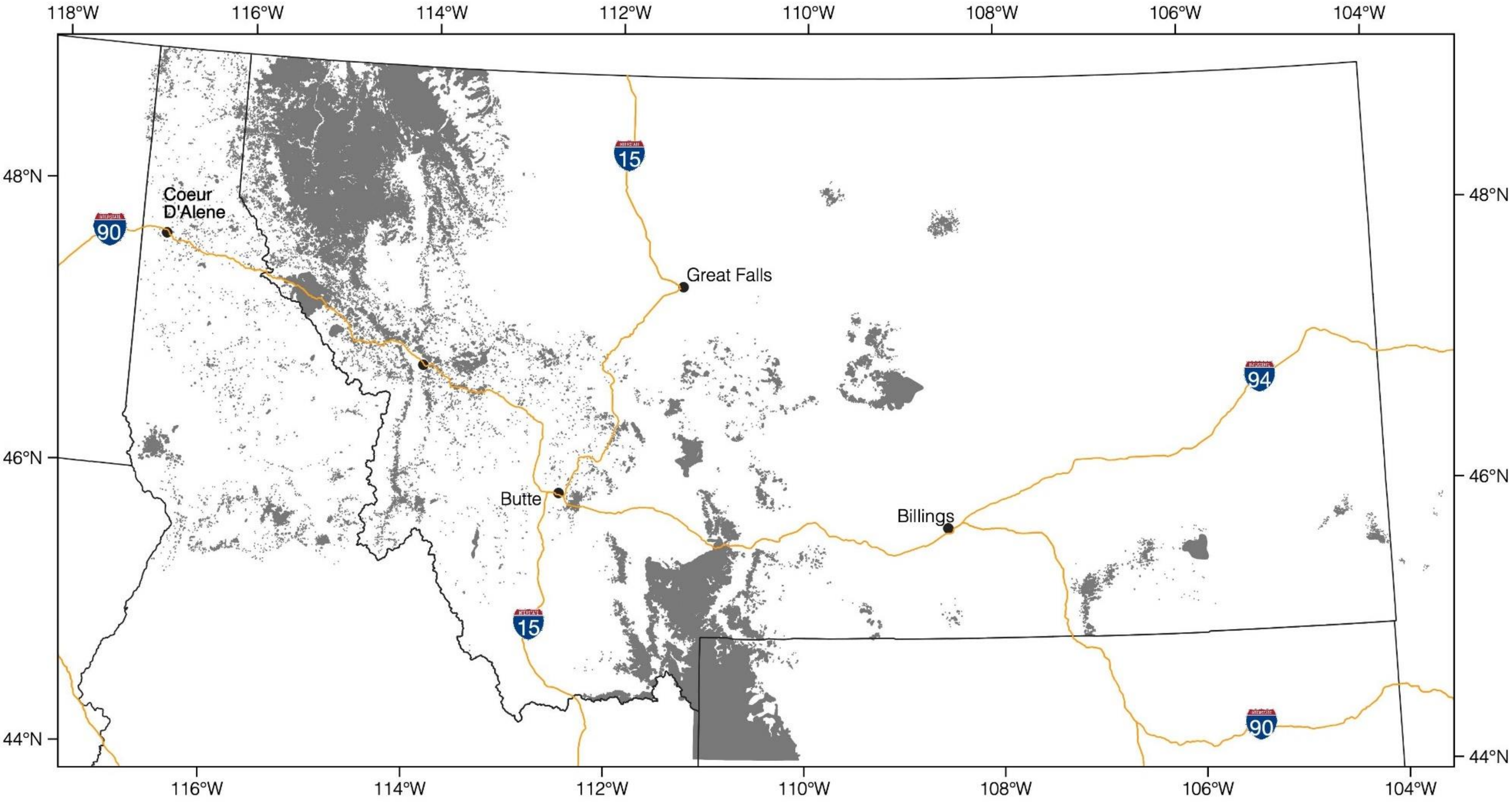
Following qualitative class designation, the area within geospatial polygons attributed with low, moderate, and high severity categories were scaled by relative midpoints, using high-severity as a baseline, to adjust area mapped to represent high-severity damage (hereafter referred to as severity-weighted area). This scaling creates a summary statistic that can be used for further aggregation totals to calculate yearly damage summations and year-to-year trends. The area within

Table 1. Table identifies qualitative severity classes defined by percent mortality ranges used for collapsing aerial detection surveys (ADS) estimates into broad categories.

polygons were adjusted simply by multiplying areas of damage mapped by the relationship between the midpoint of respective low and moderate severity % damage classes to the high severity % damage class.

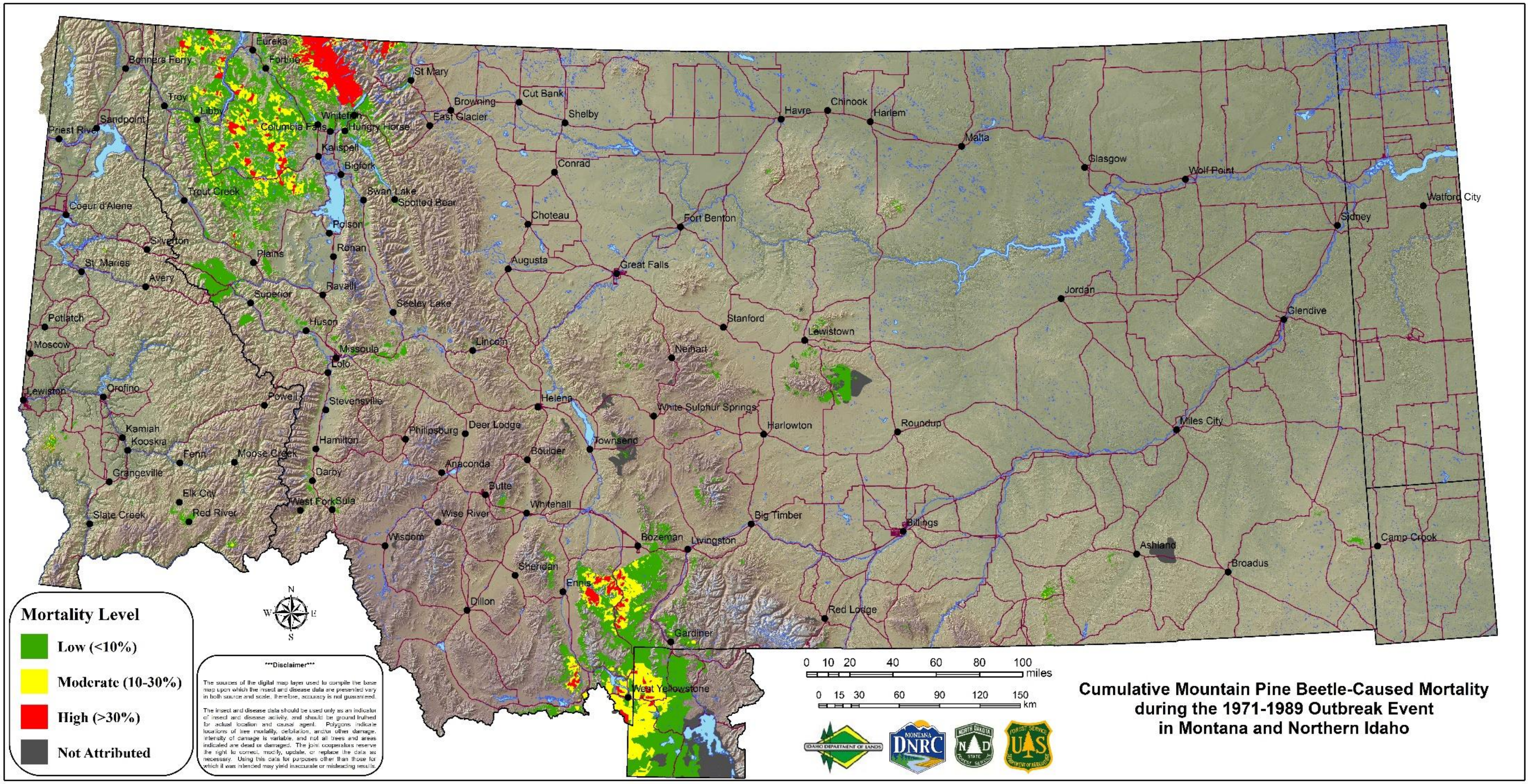
Geospatial multi-year cumulative summations

Severity-weighted area totals were summed where spatial overlap occurred in a progressive, iterative manner to spatially depict cumulative impact through time. Similarly, cumulative ‘footprint’ area impacted and severity-weighted area impacted statistics were summed from all polygons following the pre-described overlap adjustments. Validation of the recent 2000s MPB outbreak across R1 through comparisons with R1 vegetation and mortality classification products (*e.g.* Brewer et al. 2004) derived from ground plot and satellite imagery suggest ADS data, when post-processed with these methods, is reasonable to use to depict broad-scale cumulative impact estimations (Egan and Kaiden, *in preparation*).



118°W
116°W
114°W
112°W
110°W
108°W
106°W
104°W
48°N
46°N
44°N
Coeur D'Alene
Great Falls
Butte
Billings
90
15
94

Figure 3. Map showing total footprint area of MPB-caused mortality during the 1971–1989 outbreak event (6.1 million acres).


Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
Eureka
Fortine
Bonners Ferry
St Mary
Troy
Libby
Browning
Cut Bank
Shelby
Sandpoint
Priest River
Columbia Falls
Whitefish
Hungry Horse
East Glacier
Kalispell
Bigfork
Conrad
Havre
Chinook
Harlem
Malta
Glasgow
Wolf Point
Watford City
Sidney
Trout Creek
Swan Lake
Spotted Bear
Coeur d'Alene
Polson
Ronan
Choteau
Fort Benton
Silverton
Plains
St. Maries
Avery
Superior
Ravalli
Augusta
Great Falls
Seeley Lake
Jordan
Potlatch
Huson
Stanford
Glendive
Moscow
Missoula
Lolo
Lincoln
Lewistown
Neihart
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Kamiah
Kooskia
Hamilton
Philipsburg
Deer Lodge
Harlowton
Roundup
Miles City
Fenn
Moose Creek
Boulder
Townsend
Grangeville
Darby
Anaconda
Butte
Elk City
Red River
West Fork
Sula
Whitehall
Big Timber
Slate Creek
Wise River
Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone

Disclaimer

The sources of the digital map layer used to compile the base map upon which the insect and disease data are presented vary in both source and scale, therefore, accuracy is not guaranteed.

The insect and disease data should be used only as an indicator of insect and disease activity, and should be ground truthed for actual location and causal agent. Polygons indicate locations of tree mortality, defoliation, and/or other damage. Intensity of damage is variable, and not all trees and areas indicated are dead or damaged. The joint cooperators reserve the right to correct, modify, update, or replace the data as necessary. Using this data for purposes other than those for which it was intended may yield inaccurate or misleading results.

Figure 4. Map showing total cumulative MPB-caused mortality area during the 1971–1989 outbreak event (6.1 million acres) classified by severity of mortality.

1980s Mountain Pine Beetle Outbreak Attributes

Area Impact Totals for MPB Outbreak from 1971–1989

The 1971–1989 MPB outbreak event resulted in a total mortality footprint of over 6.1 million ac (Table 2; Figure 3). Of the total 6.1-ac impact area, > 800,000 ac and 627,000 ac were classified as moderate and high severity, respecitvely (Table 2). Figure 4 shows a map of the total cumulative MPB-caused mortality area during the 1980s event classified by mortality severity level. For cumulative and individual-year maps of MPB-caused mortality weighted by severity, see Appendices 1 and 2. Overall, by far the broadest expanse of the most severe mortality was experienced along the east side of the Lewis Range, just north of Whitefish, MT, followed by the Madison/Gallatin Range area of southwest MT bordering Yellowstone National Park (Figure 4).

Table 2. Total area (acres) of MPB-caused mortality during the 1971–1989 outbreak event classified by moderate severity, high severity, and total area.

	Total Moderate Severity acres	Total High Severity acres	Total Area acres
1980s Outbreak	800,839	627,633	6,115,042

Temporal Progression and Yearly Trends in MPB Outbreak from 1971–1989

The 1980s MPB outbreak lasted for 19 years during the period 1971–1989. The outbreak started with low mortality levels during 1971, with the largest contiguous mortality located near the towns of Huson, MT and Missoula, MT, along the west-central area of R1. The footprint of infested area at the start of the outbreak in 1971was just over 530,000 ac (532,708 ac). The total footprint area remained < 1,000,000 ac until 1976, during which the infested area increased to 1,144,951 ac, before decreasing during 1977 and 1978. Yet, while there appeared to be little-to-no change in the footprint area during the 1977–1978 period (Figure 5), interpreting trends in ADS

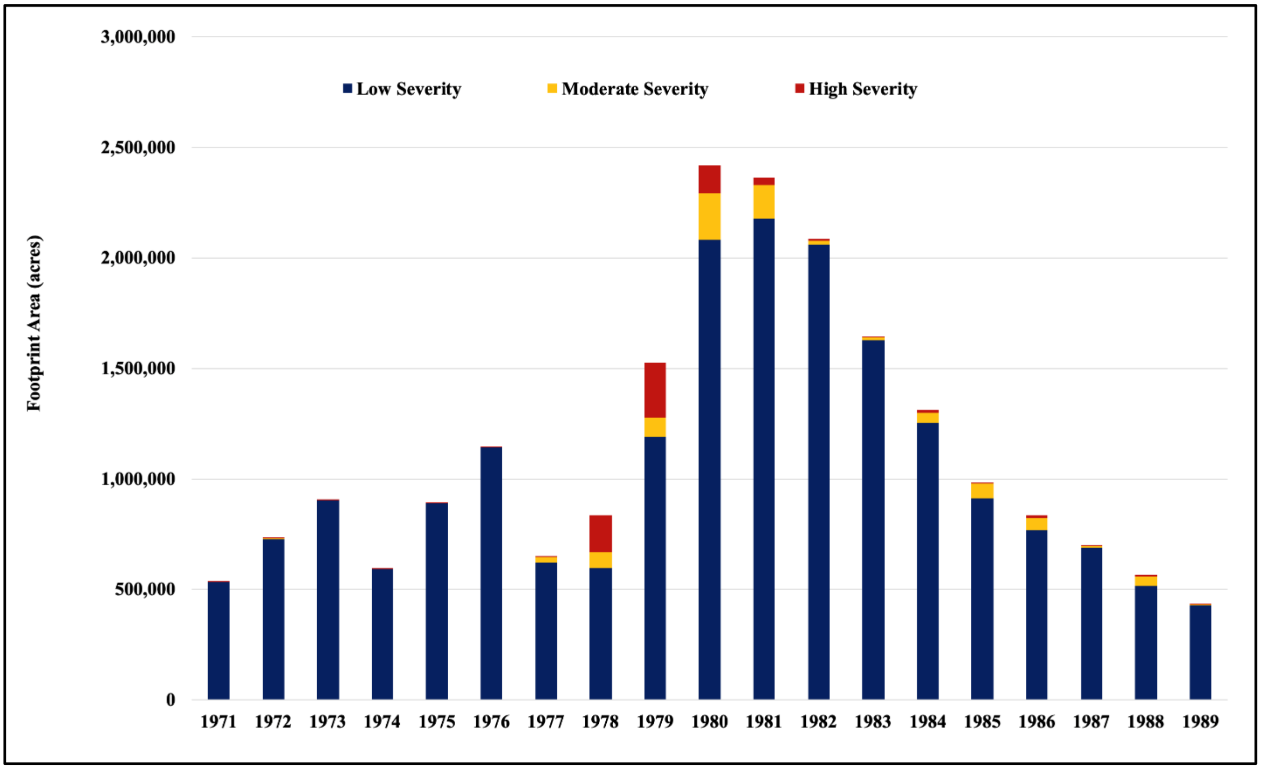


Figure 5. Histogram showing footprint area by severity (low, moderate, high) depictions of MPB-caused tree mortality mapped during the 1980s outbreak period across the Northern Region.

data for comparison purposes should be done using the severity-weighted statistic. The greatest increase in severity-weighted area occurred from 1977 to 1978 (Figure 6A), during which there was a 279% increase in ac (Figure 6B). This is consistent with the onset of the rapid increase in moderate-to-high severity areas (Figures 5, 6). This elevated period of MPB severity lasted for *ca.* 5 years from 1977 to 1981, after which the footprint area and severity-weighted area decreased exponentially until the end of this defined outbreak. Two important distinctions from comparing the raw footprint area and the severity-weighted area are the incorrect identifications of [1] the peak outbreak onset year and [2] the peak outbreak year that occur with footprint area statistics. If only the raw footprint area numbers are considered, the onset of the peak outbreak appears to be

1979 and the peak outbreak year appears to be 1980. However, after adjusting for damage mapped within polygons, the severity-weighted area totals indicate the timing of peak outbreak begins in 1978 and the peak outbreak year is 1979. This serves as an example of the importance of using severity-weighted area when analyzing trends in outbreak data.

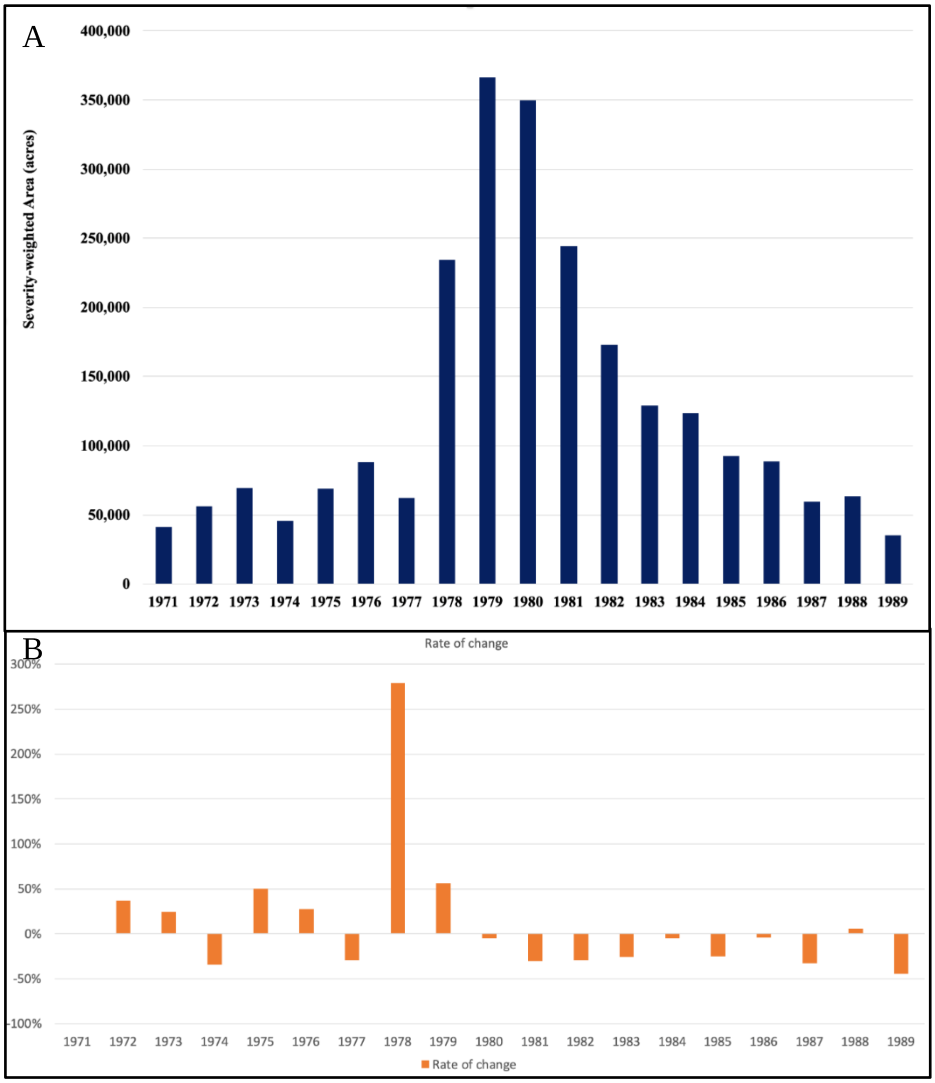


Figure 6. Histogram showing (A) severity-weighted area depictions of MPB-caused tree mortality mapped during the 1980s outbreak period across the Northern Region and (B) the rate of change (percentage) in severity-weighted acreage in year identified relative to the prior year.

The rate of change in severity-weighted area time series shows a general trend of positive rates of change starting with 37% from 1971 to 1972 at the start on the outbreak, and this trend continues until 1979 (except for 1973–1974 and 1976–1977). After 1979, the general trend in rate of change switches to negative values (except for a +6% change from 1988 to 1989) toward the end of the outbreak (Figure 6B).

Elevation

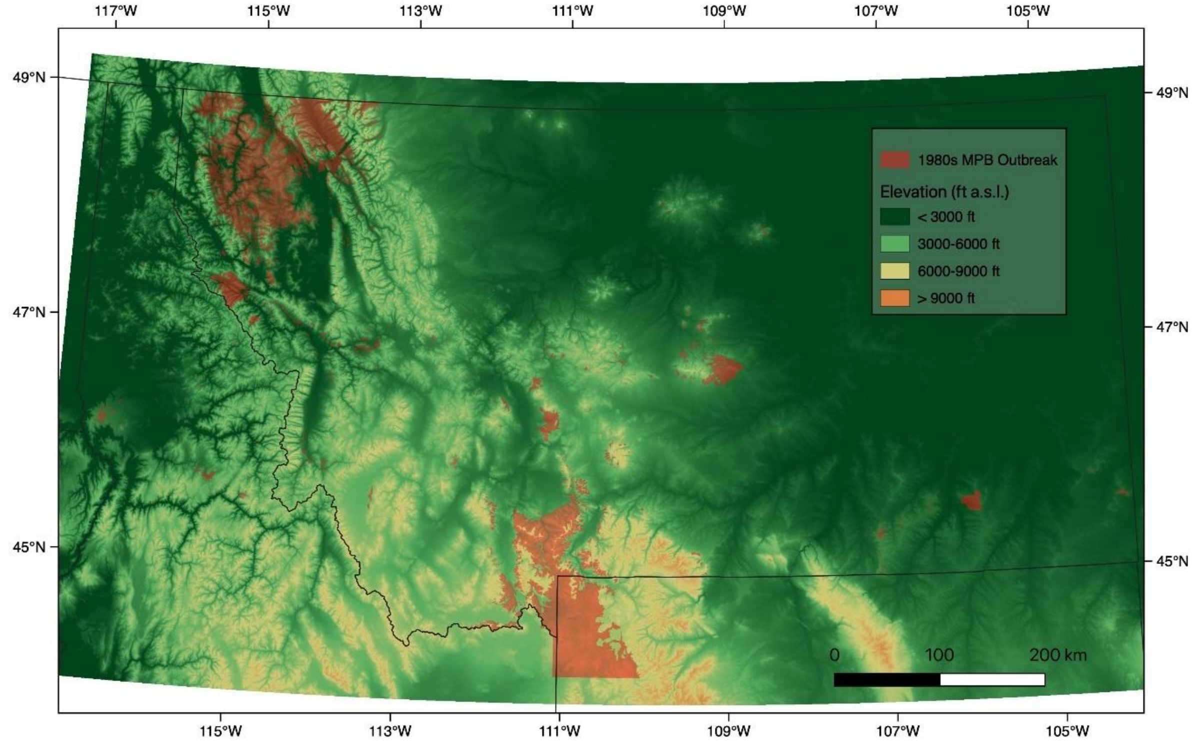

117°W
115°W
113°W
111°W
109°W
107°W
105°W
49°N
47°N
45°N
1980s MPB Outbreak
Elevation (ft a.s.l.)
< 3000 ft
3000-6000 ft
6000-9000 ft
> 9000 ft
0
100
200 km

Figure 7. Map showing the total footprint area of the 1980s outbreak plotted with elevation range across the Northern Region.

Elevation across RI is highly variable and dissected, especially given the distribution of the Northern Rocky Mountains within the Region. Here, elevation ranges from *ca.* 1,312 ft to 14,764 ft a.s.l. (Figure 7). The spatial footprint of the 1980s outbreak is unique spatially, as seen in Figures 3 & 4, with two geographic concentrations of [1] the Great Yellowstone Ecoregion and [2] the Salish Mountains area of northwest Montana. A third area of MPB activity occurred in central Montana around the Little Snowy Mountains region (near Lewiston, MT), but this area is substantially smaller compared to the Yellowstone and northwest Montana outbreak areas. Elevations in these three areas also differs. The greatest elevations with regard to the 1980s outbreak sectors, occurs in Yellowstone, with elevations ranging from 6,000 to > 9,000 ft a.s.l. Elevation ranges for the northwest and central Montana regions is less, with areas falling between 3,000 and 6,000 ft. Across the 1980s outbreak footprint, the largest infected area occurs at the

3,000–6,000 ft elevation group (3,360,782.7 ac), which is 54.9% of the total 6,115,041.8 ac (Table 2). This is followed by the 6,000–9,000 ft elevation group with a total area of 2,570,392.4 ac (42.0% of total). The elevation groups at the tails of the distribution, < 3,000 ft and > 9000 ft, have similar impacted areas of 92,179.5 ac and 91,687.5 ac, respectively, both *ca.* 1.5% of the total area.

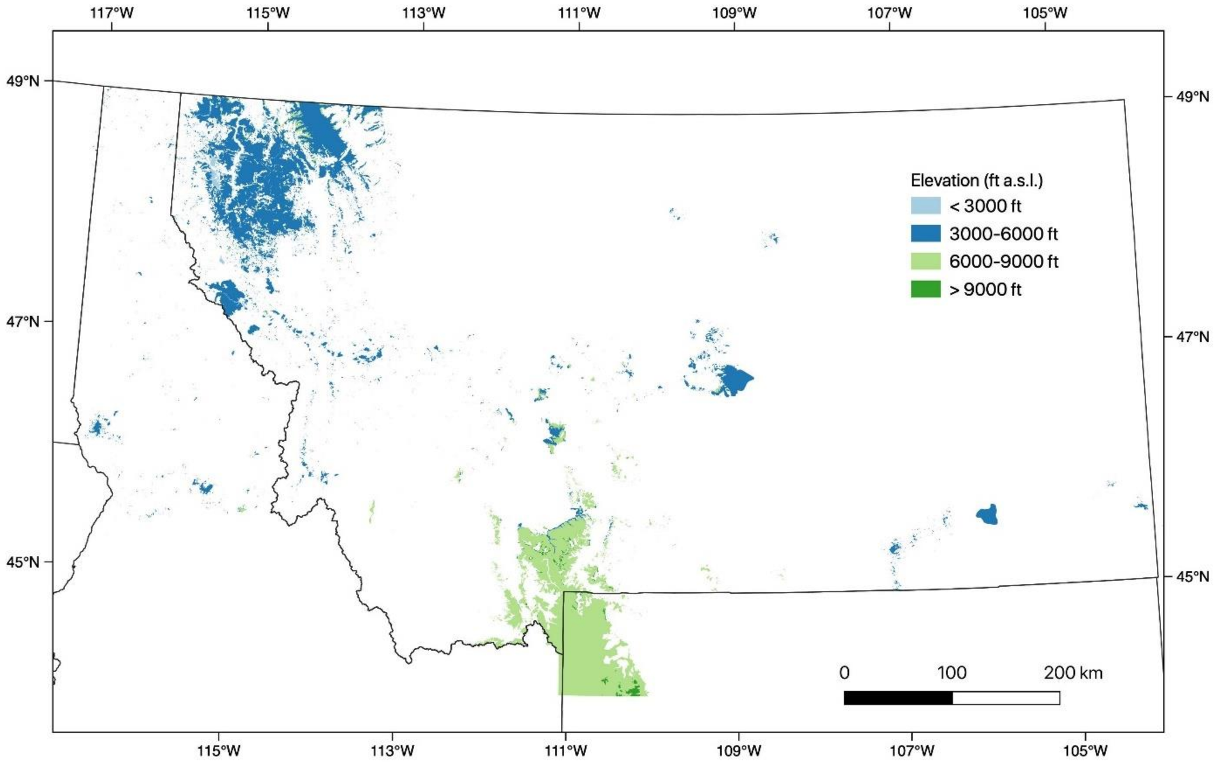

117°W
115°W
113°W
111°W
109°W
107°W
105°W
49°N
47°N
45°N
Elevation (ft a.s.l.)
< 3000 ft
3000-6000 ft
6000-9000 ft
> 9000 ft
0
100
200 km

Figure 8. Map showing the total footprint area of the 1980s outbreak classified by biological elevation (feet above sea level) groups across the Northern Region.

Table 3. Total area (acres) of the 1980s outbreak classified by elevation (ft).

	Total Area (ac)	**< 3000 ft**	**3000–6000 ft**	**6000–9000 ft**	**> 9000 ft**
1980s Outbreak	6,115,041.8	92,179.5	3,360,782.7	2,570,392.4	91,687.5
% of total	—	1.5%	54.9%	42.0%	1.5%

Species Impacted

A total of 5 primary species acted as hosts during the 1971–1989 MPB outbreak event: *Pinus albicaulis* (whitebark pine), *P. flexis var. reflexa* (limber pine); *P. monticola* (western white pine), *P. ponderosae* (ponderosa pine) and *P. contorta* (lodgepole pine) (Figure 8). Out of the 5 identified species impacted by the 1980s outbreak, by far the most mortality was experienced by lodgepole pine (Table 4). Of the total footprint area of the outbreak (6.1 million acres), approximately 4.8 million acres were lodgepole pine-dominated forests (79.9%). Ponderosa pine-dominated forests were impacted across approx. 835,000 acres (13.7%). Together, ponderosa pine and lodgepole pine accounted for 93.6% of the total area impacted during the 1980s outbreak.

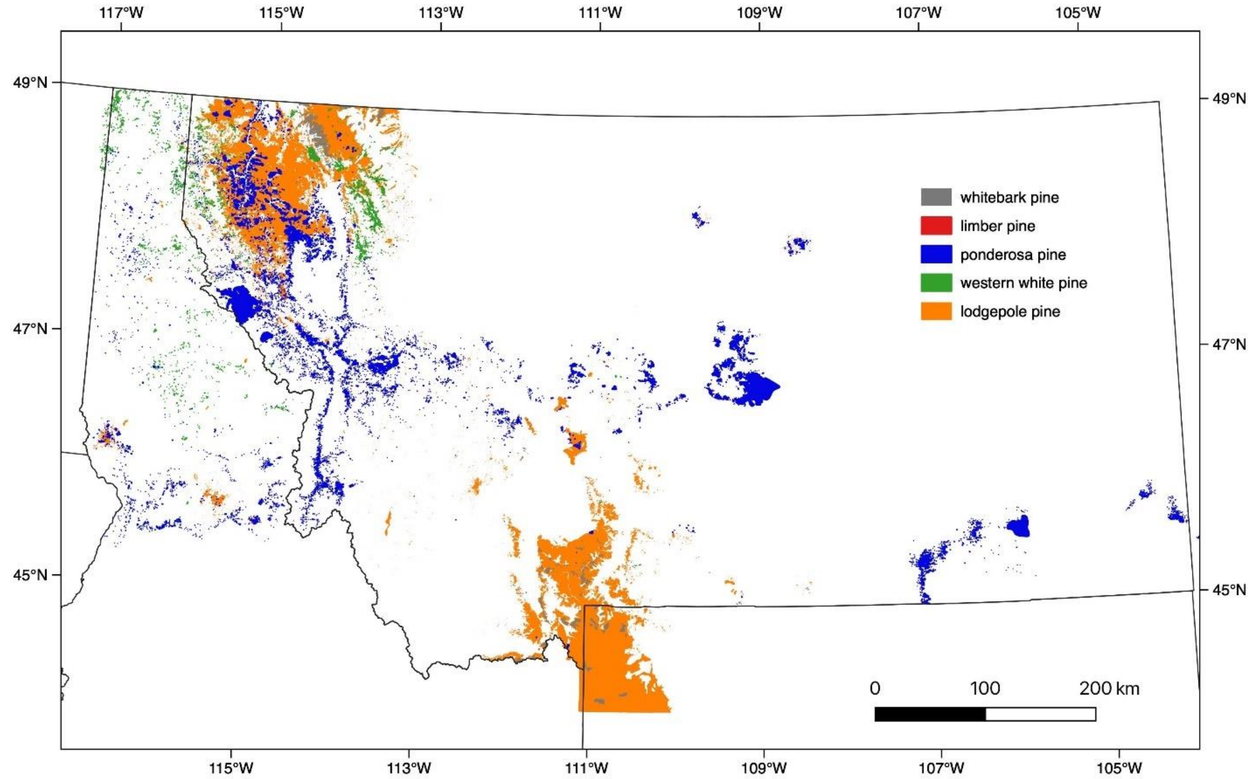

117°W
115°W
113°W
111°W
109°W
107°W
105°W
49°N
47°N
45°N
whitebark pine
limber pine
ponderosa pine
western white pine
lodgepole pine
0
100
200 km

Figure 9. Map showing the total footprint area of the 1980s outbreak classified by species impacted across the Northern Region.

Some spatial patterns arose when the outbreak was mapped by species impacted. Most area impacted in the Yellowstone area was classified as lodgepole pine-dominated forests, whereas mortality in northwest Montana was more evenly split across species (Figure 9).

Table 4. Total area (acres) of the 1980s outbreak classified by species impacted.

	whitebark pine *(Pinus albicaulis)*	**limber pine** *(P. flexis* var. *reflexa)*	**ponderosa pine** *(P. ponderosae)*	**western white pine** *(P. monticola)*	**lodgepole pine** **(***P. contorta***)**
1971-1989 Acres	324,158	72	834,939	68,246	4,887,627
% of total	5.3%	0.001%	13.7%	1.1%	79.9%

Environmental Drought Association

Drought is a common feature of the US climate, and our understanding of how past hydroclimate variability might influence the spread and intensification of insect outbreaks helps to explain linkages between the climate and terrestrial systems. Instrumental Palmer Drought Severity Index (PDSI; Palmer 1965), a common metric of drought and hydroclimate conditions ranked on a scale from 6 (exceptionally wet) to -6 (exceptionally dry), shows overall soil moisture conditions during the 1971–1989 outbreak were generally drier than normal (Figure 10). During the 19-year outbreak, only 4 years (1975, 1976, 1981, 1982) were > 1,

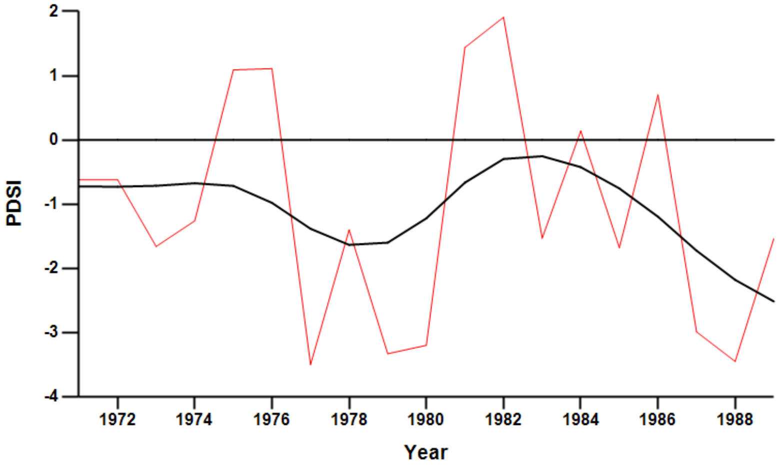


Figure 10. Variability of instrumental Palmer Drought Severity (PDSI; Palmer 1965; red) contemporary with the period of the 1971–1989 MPB outbreak event shown with a 10-year smoothing spline (black). Data shown centered at 44.74 °N, 110.64 °W. Figure generated from: http://www.drought.memphis.edu

demonstrating abnormally wet conditions. Further, the record shows two distinct drought events over the region of outbreak (1977–1980; 1987–1989).

Starting in 1971, hydroclimate conditions show a common variability between abnormally dry and abnormally wet conditions until 1976, after which soil conditions become severely dry. These drought conditions continue until 1980, after which soil moisture recovers to abnormally wet conditions in 1981 and 1982 before returning to dry conditions. A second drought event occurs in 1987–1989 (classified as severely dry), until the end of the defined 1980s outbreak. Coincidentally, the 1971–1989 outbreak event experiences peak mortality from 1978 to 1980, consistent with the severely dry soil moisture event. Often, adverse climate conditions in a given year will have precedent effects on tree health and growth during the following year (Fritts 1976). We also see this occurring between drought and rapid, increased tree mortality during the outbreak, such that

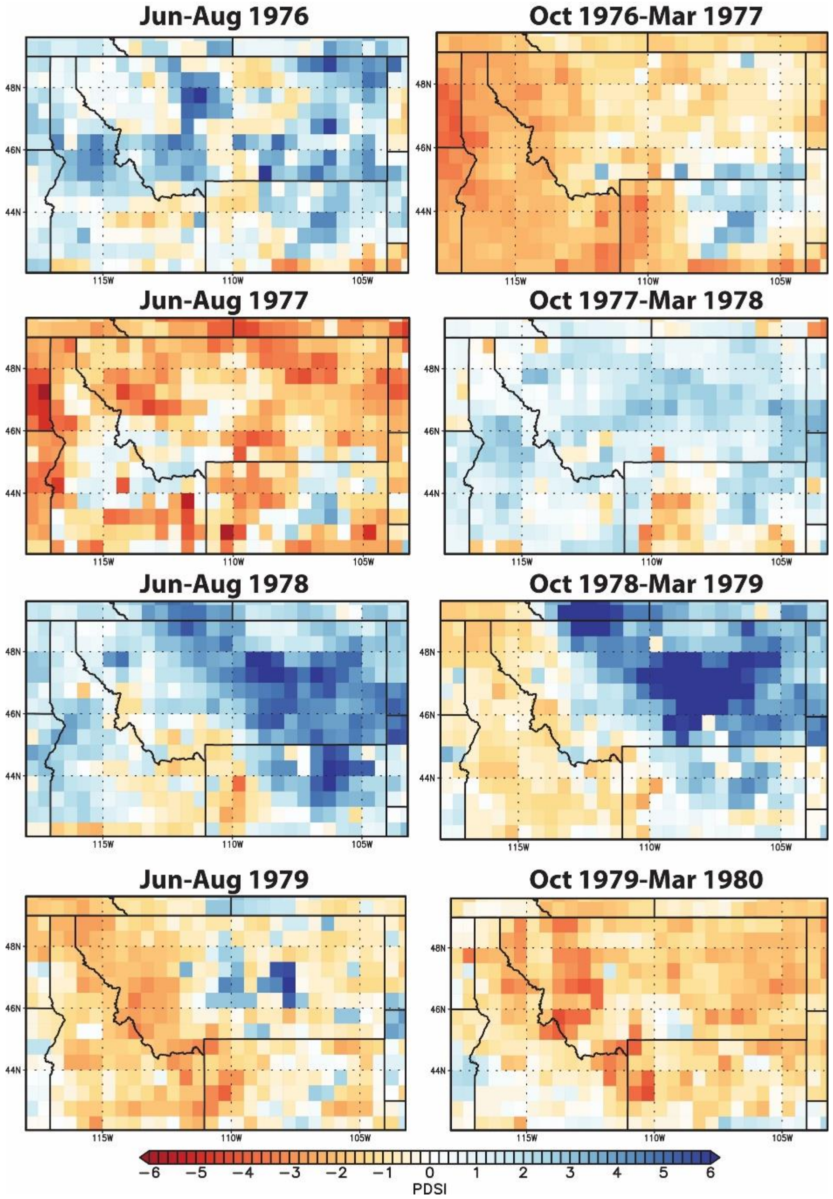

Jun-Aug 1976
Oct 1976-Mar 1977
Jun-Aug 1977
Oct 1977-Mar 1978
Jun-Aug 1978
Oct 1978-Mar 1979
Jun-Aug 1979
Oct 1979-Mar 1980
48N
46N
44N
115W
110W
105W
−6
−5
−4
−3
−2
−1
0
1
2
3
4
5
6
PDSI

Figure 11. Maps showing spatial warm season (June–August) and cool season (October–March) drought variability (PDSI) during the period 1976–1980 across Region 1. Figures generated from http://www.drought.memphis.edu

severely dry conditions in 1977 likely contributed to the *ca.* 275% rate of change mortality increase between 1977 and 1978 (Figure 6AB).

This coeval pattern of drought and increased rate of change in MPB-caused mortality is also demonstrated in the spatial PDSI maps, and interesting patterns are revealed when cool- (Oct–Mar) and warm- (Jun–Aug) season precipitation is considered (Figure 11). The seasonal analysis shows that the 1977–1980 drought occurs over the entire outbreak region with excessively-severely dry soil moisture conditions during the cool season of Oct 1976–Mar 1977. Dry conditions persist over R1 through August 1977. Although soil moisture is slightly increased during 1978, conditions remain drier than average before worsening in 1979. After 1979, the only year with a positive rate of change, although small (6%), is 1988. This is a noteworthy year, given this increase in severity-weighted mortality area occurs at the tail end of the outbreak event. Yet, summer (June–August) conditions during 1988 were some of the driest that occurred during the entire outbreak (Figure 12). Even with these severely dry conditions, MPB activity continued to decline from 1988-1989, with 1989 being identified as the last year of the outbreak event.

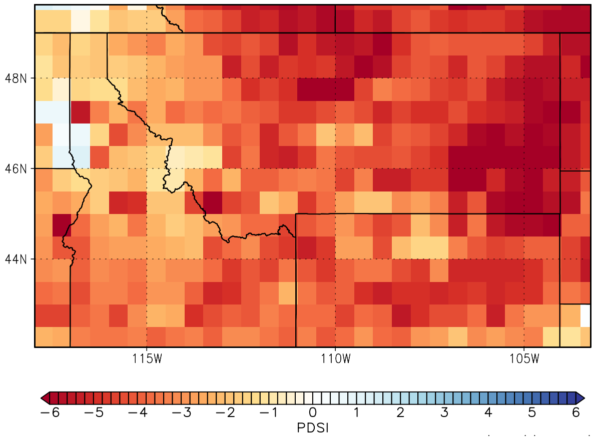


Figure 12. Map showing spatial drought variability (PDSI) during June–August 1988 across Region 1. Figure generated from http://www.drought.memphis.edu

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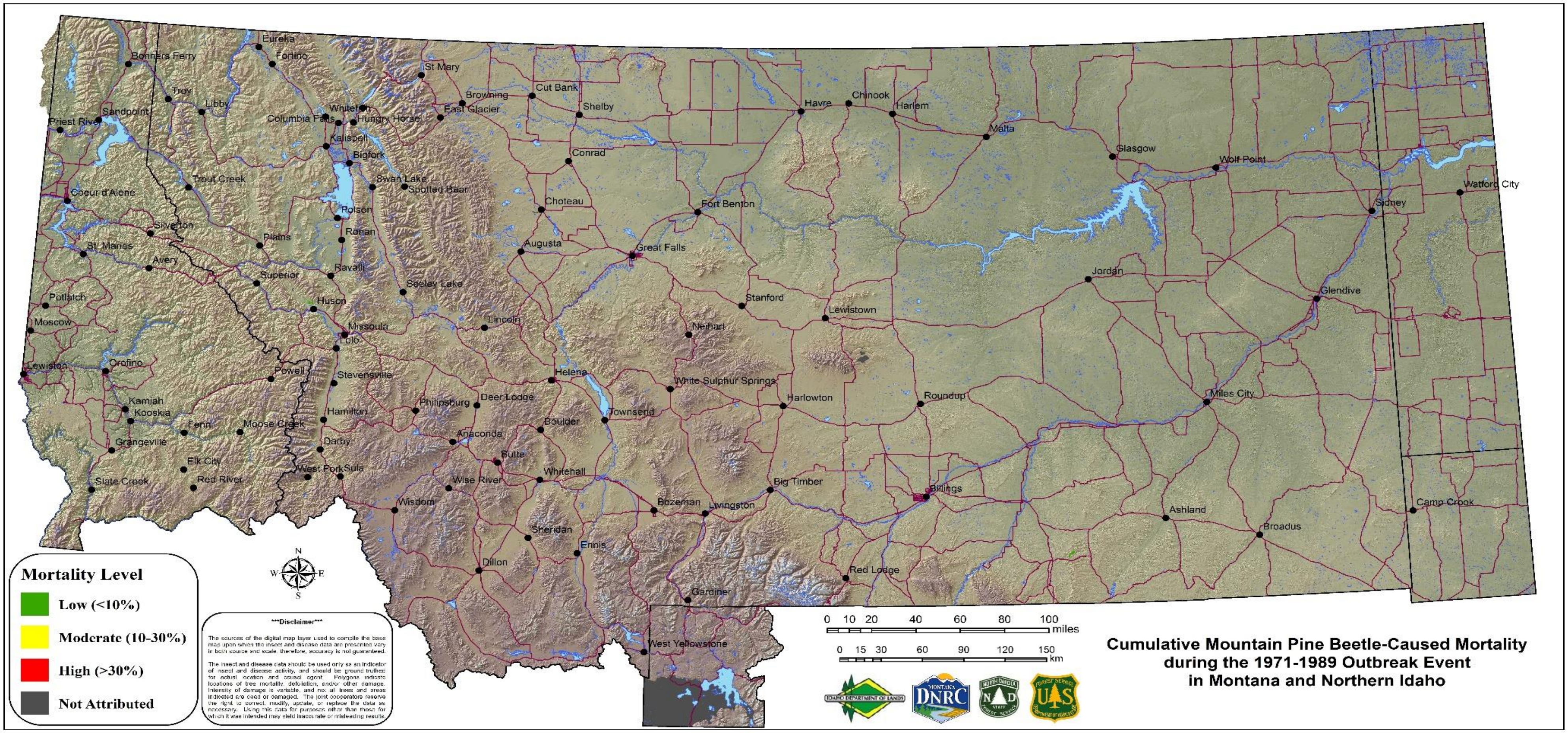
Citation for this report:

Harley, G., Egan, J., Jenne, J., Kaiden, J., McGee, J., Gibbs, R. 2019. Broad-level Reconstruction of Mountain Pine Beetle Outbreak Spatial Extent and Impacts throughout Montana and northern Idaho from 1971–1989. R1-19-08. USDA Forest Service. U.S. Department of Agriculture, Forest Service, Forest Health Protection, Missoula. 57 p.

Appendix 1: Maps showing total cumulative MPB-caused mortality area during each year of the 1971–1989 outbreak event (total 6.1 million acres) classified by severity of mortality estimated through aerial detection surveys.

1971: Mountain pine beetle-caused mortality estimated by ADS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Elk City
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Slate Creek
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IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Mortality Level

- 🟩 Low (<10%)
- 🟨 Moderate (10-30%)
- 🟥 High (>30%)
- ⬛ Not Attributed

Disclaimer

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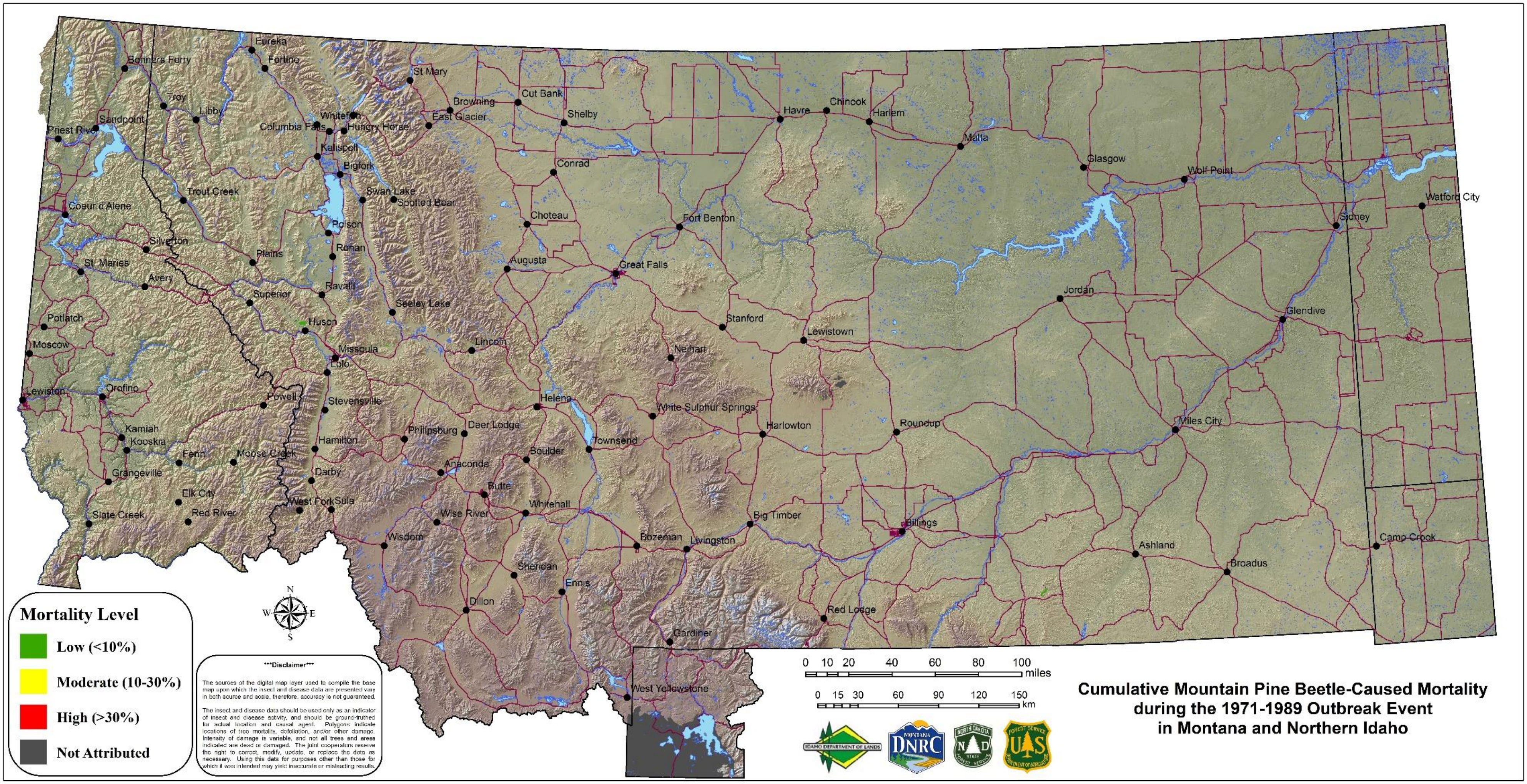
Cumulative Mountain Pine Beetle-Caused Mortality during the 1971-1989 Outbreak Event in Montana and Northern Idaho

1971–1972: Cumulative mountain pine beetle-caused mortality estimated by ADS


Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
Mortality Level
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🟨 Moderate (10-30%)
🟥 High (>30%)
■ Not Attributed
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Cut Bank
East Glacier
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Harlem
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Fort Benton
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Coeur d'Alene
Swan Lake
Spotted Bear
Polson
Ronan
Silverton
St. Maries
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Avery
Superior
Ravalli
Seeley Lake
Potlatch
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Elk City
Red River
Slate Creek
West Fork
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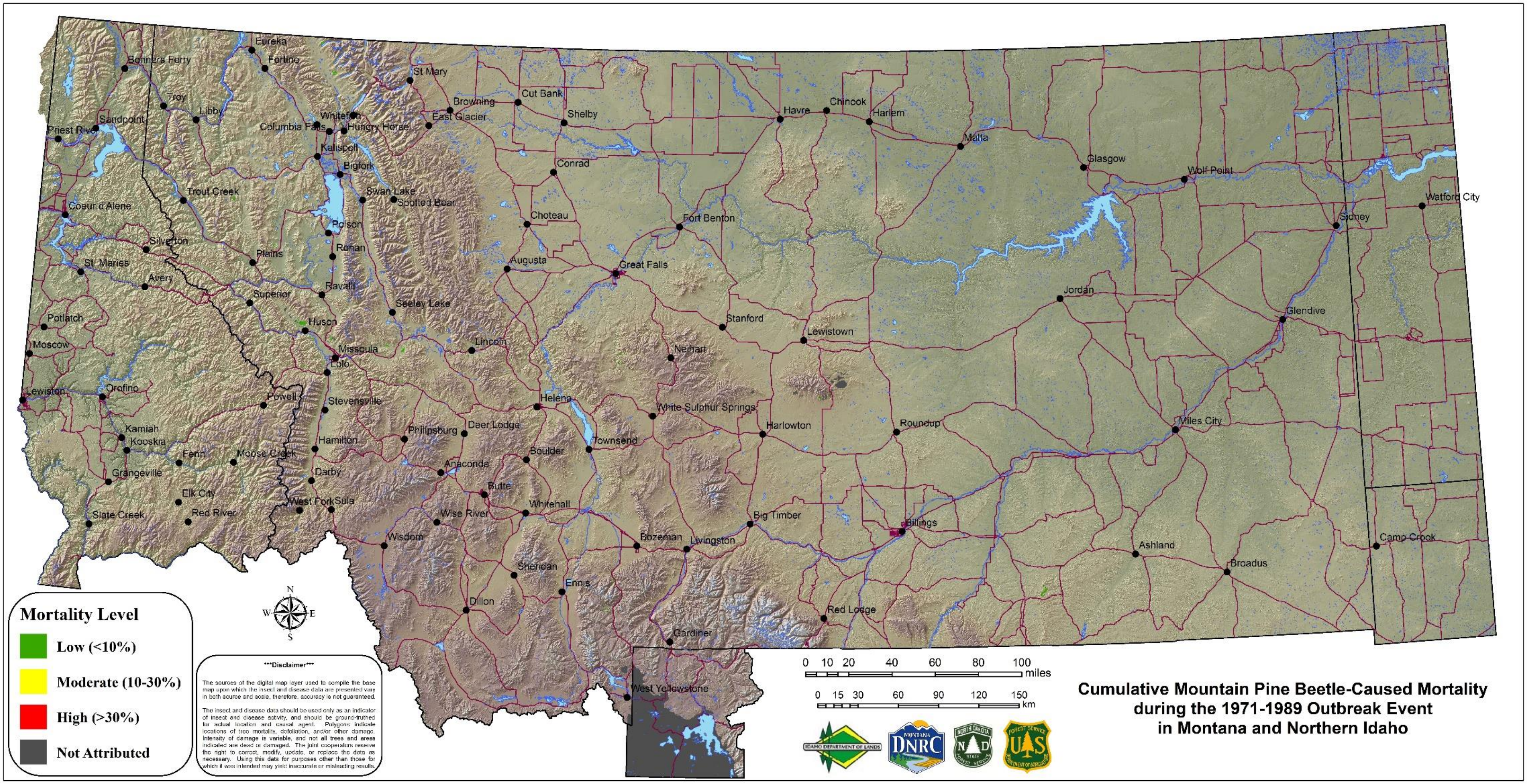
1971–1973: Cumulative mountain pine beetle-caused mortality estimated by ADS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🟨 Moderate (10-30%)
🟥 High (>30%)
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IDAHO DEPARTMENT OF LANDS
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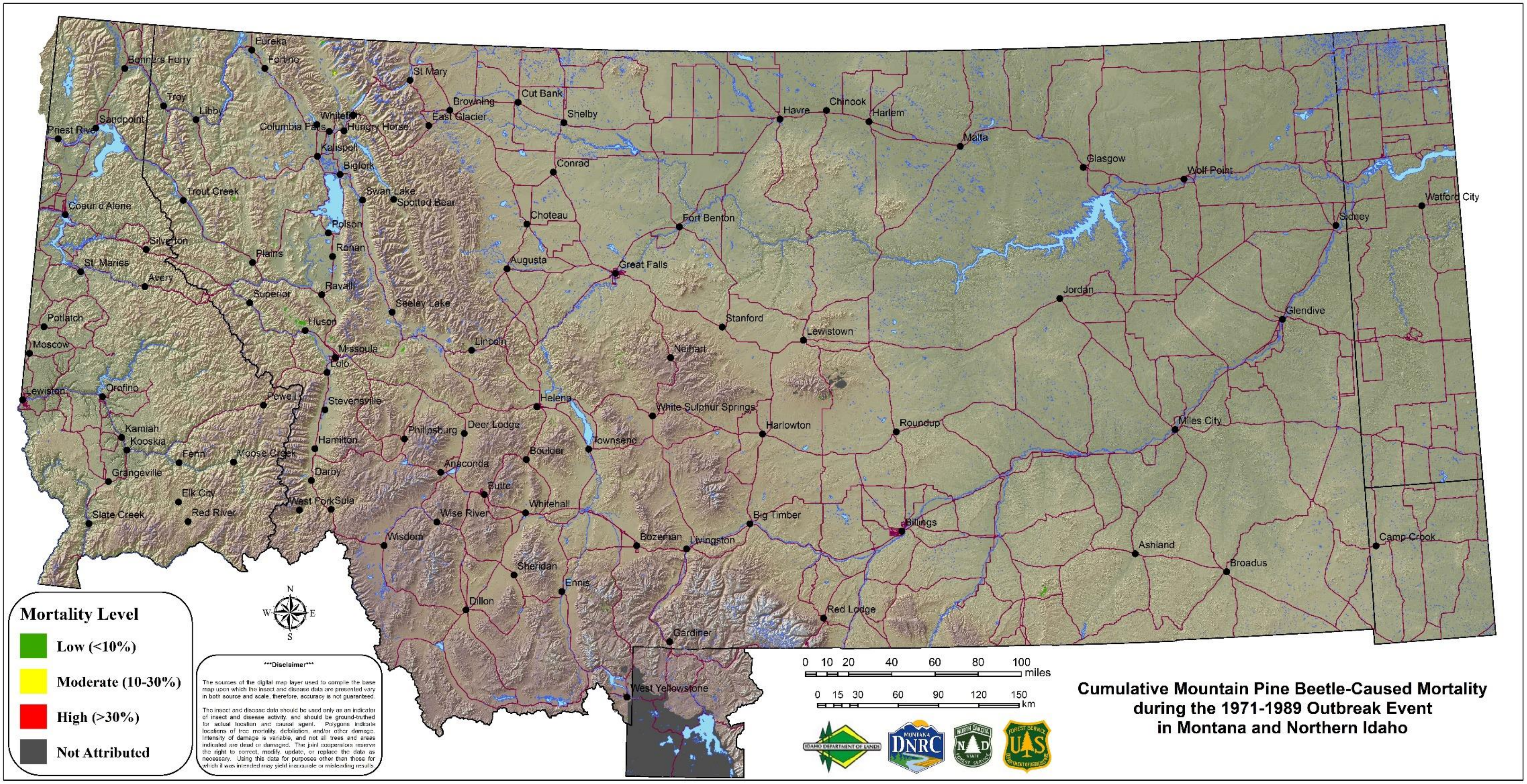
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

1971–1974: Cumulative mountain pine beetle-caused mortality estimated by ADS


Mortality Level
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Moderate (10-30%)
High (>30%)
Not Attributed
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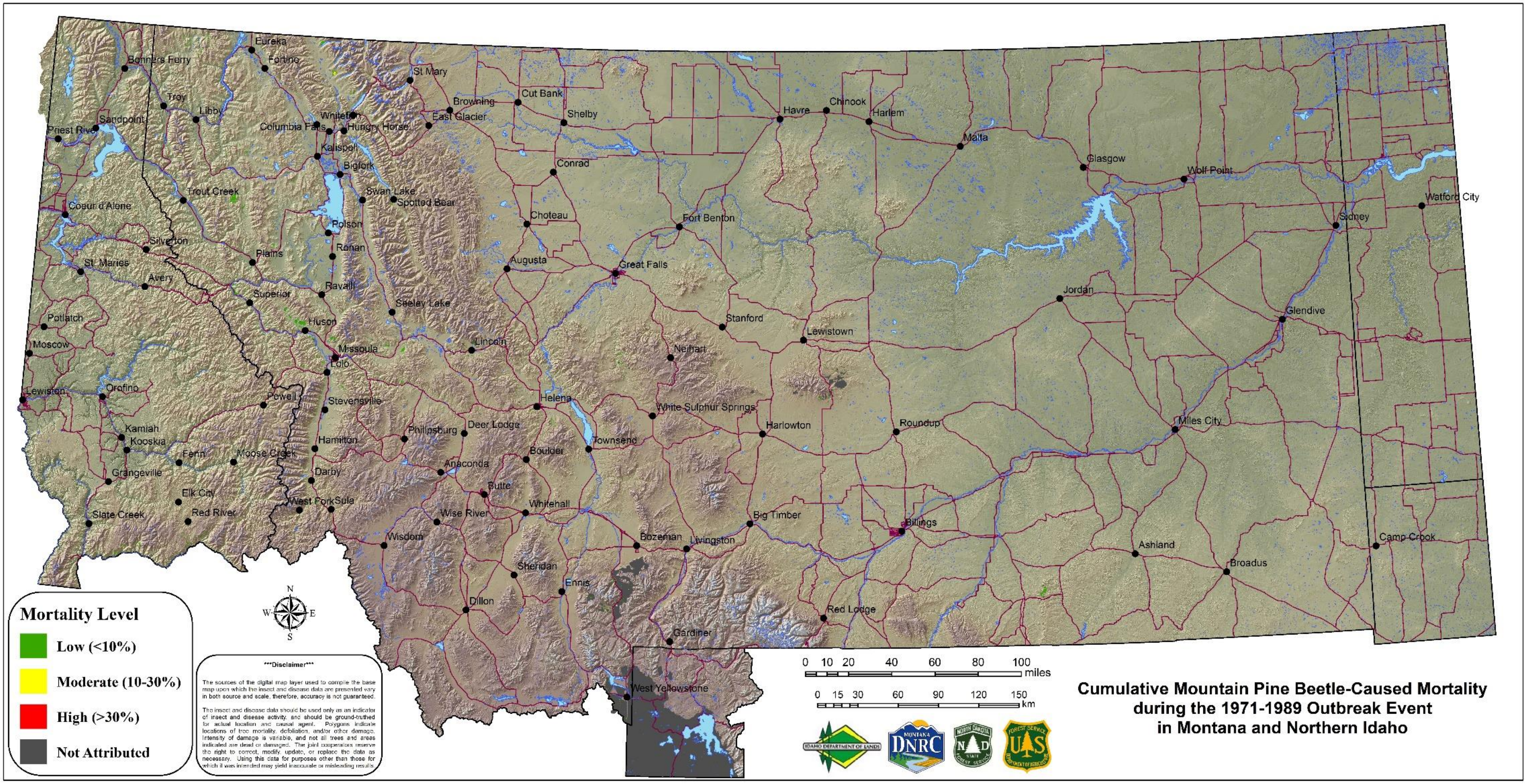
Cumulative Mountain Pine Beetle-Caused Mortality during the 1971-1989 Outbreak Event in Montana and Northern Idaho

1971–1975: Cumulative mountain pine beetle-caused mortality estimated by ADS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Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
0 10 20 40 60 80 100 miles
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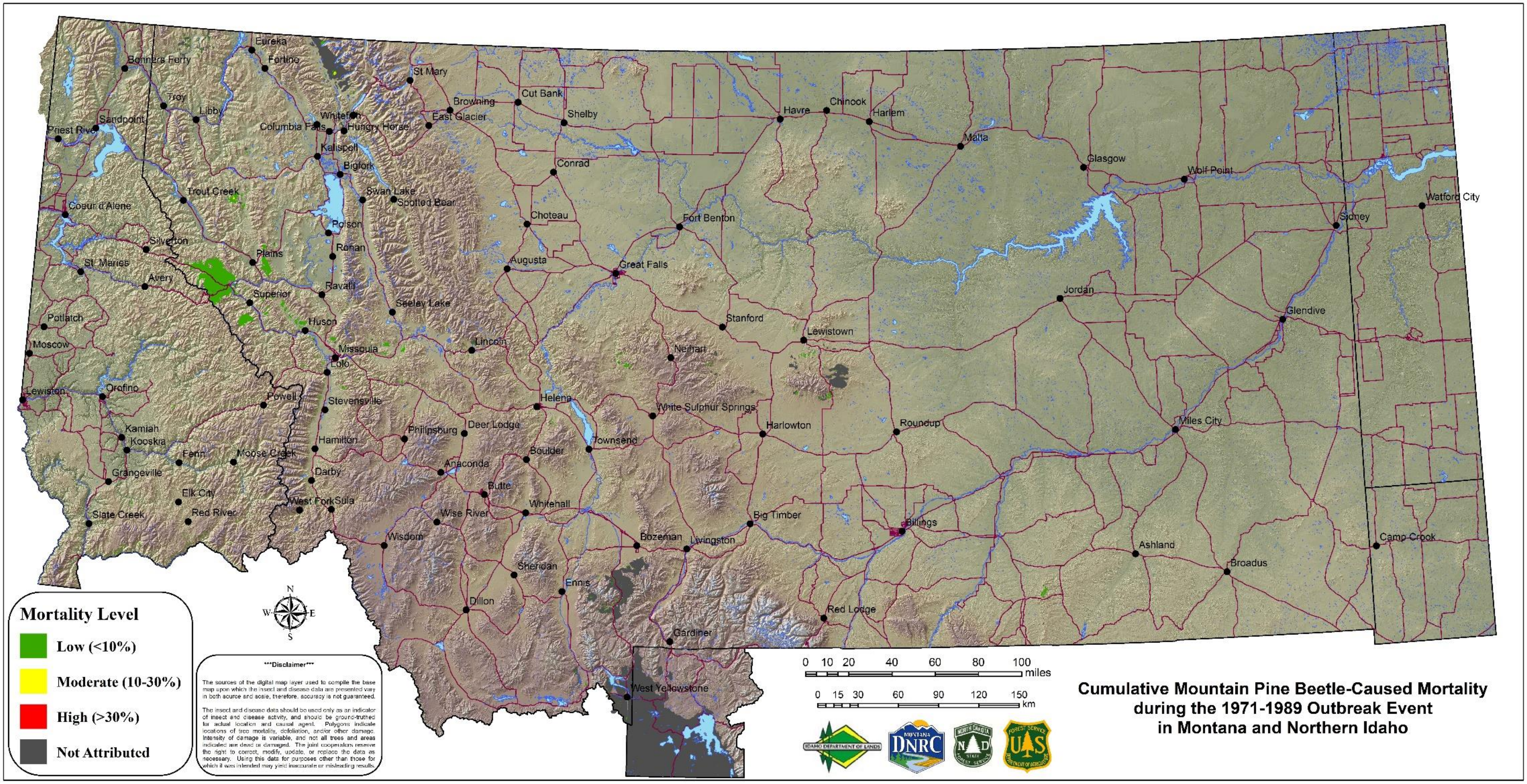
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

1971–1976: Cumulative mountain pine beetle-caused mortality estimated by ADS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IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Mortality Level

- 🟩 Low (<10%)
- 🟨 Moderate (10-30%)
- 🟥 High (>30%)
- ⬛ Not Attributed

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Cumulative Mountain Pine Beetle-Caused Mortality
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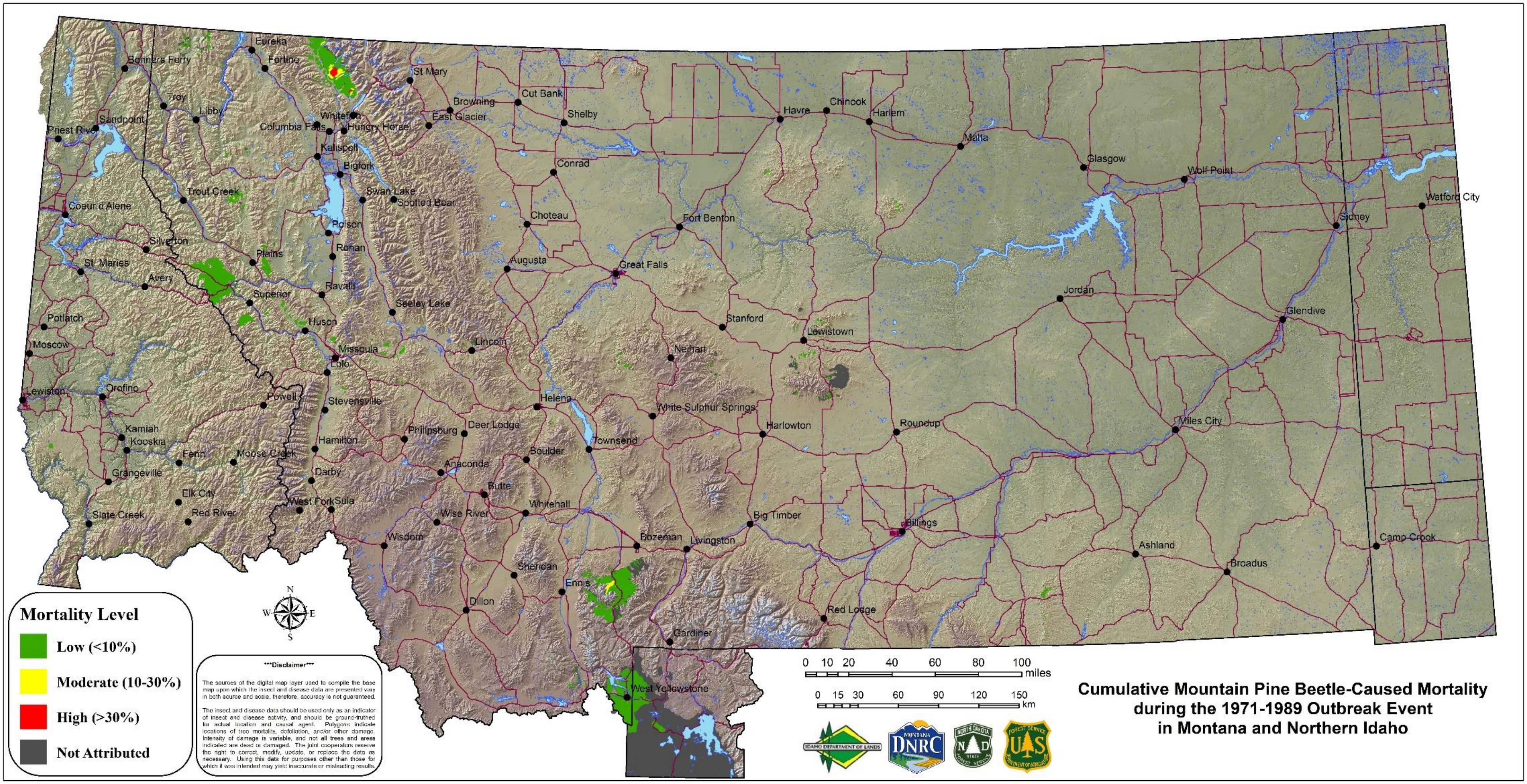
in Montana and Northern Idaho

1971–1977: Cumulative mountain pine beetle-caused mortality estimated by ADS


Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
Mortality Level
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High (>30%)
Not Attributed
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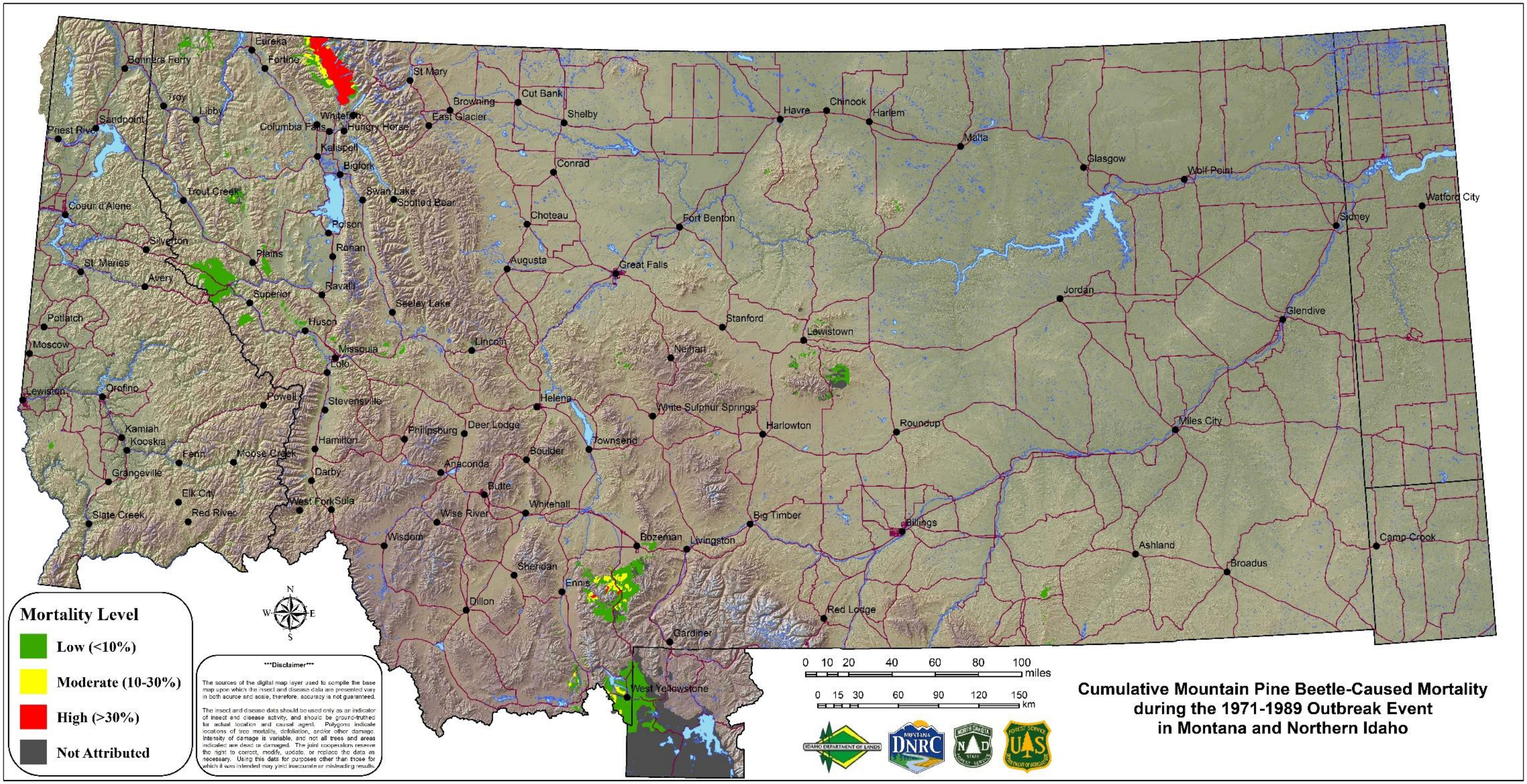
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IDAHO DEPARTMENT OF LANDS
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NORTH DAKOTA N D STATE FOREST SERVICE
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Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

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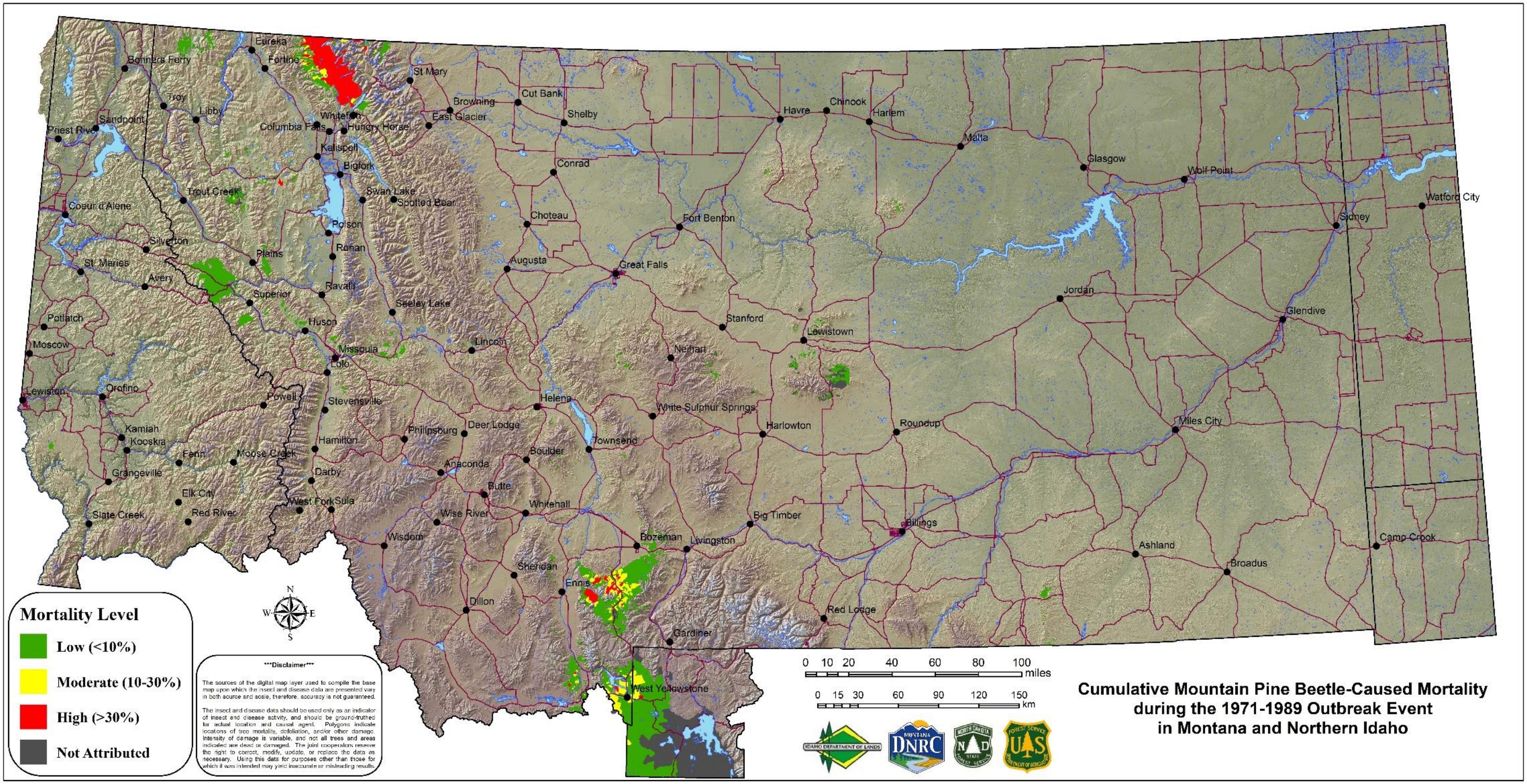
Mortality Level
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🟥 High (>30%)
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0 15 30 60 90 120 150 km
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
Eureka
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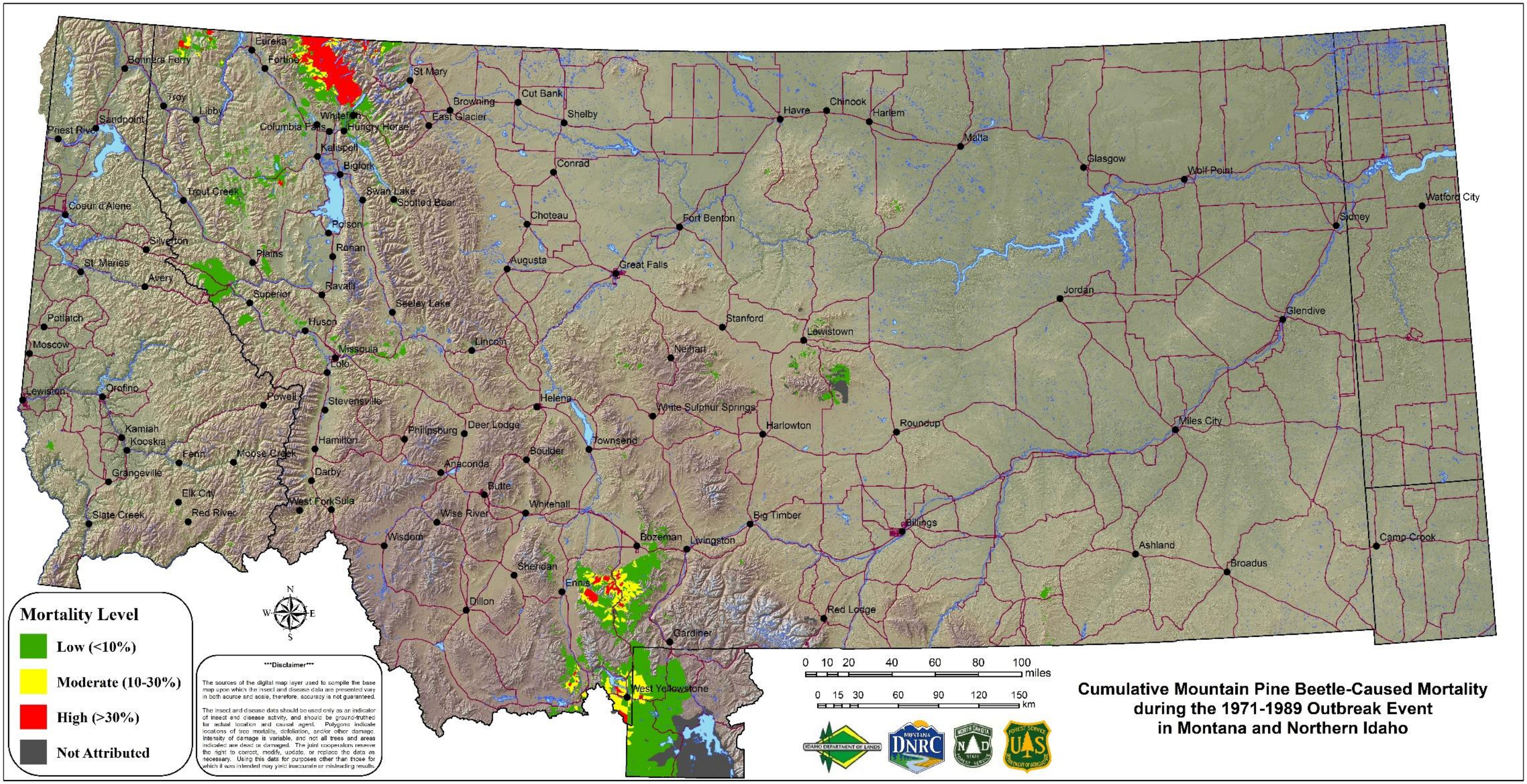
1971–1980: Cumulative mountain pine beetle-caused mortality estimated by ADS


Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA STATE FOREST SERVICE
FOREST SERVICE
Eureka
Fortine
Bonners Ferry
Troy
Libby
Sandpoint
Priest River
St Mary
Browning
Cut Bank
East Glacier
Shelby
Whitefish
Columbia Falls
Hungry Horse
Kalispell
Bigfork
Havre
Chinook
Harlem
Malta
Glasgow
Wolf Point
Watford City
Sidney
Conrad
Trout Creek
Swan Lake
Spotted Bear
Coeur d'Alene
Polson
Choteau
Fort Benton
Silverton
Ronan
St. Maries
Plains
Augusta
Great Falls
Avery
Ravalli
Superior
Seeley Lake
Jordan
Glendive
Potlatch
Huson
Stanford
Lewistown
Moscow
Missoula
Lincoln
Neihart
Lolo
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Kamiah
Kooskia
Philipsburg
Deer Lodge
Harlowton
Roundup
Miles City
Hamilton
Townsend
Fenn
Moose Creek
Boulder
Anaconda
Grangeville
Darby
Butte
Elk City
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
Big Timber
Billings
Wisdom
Bozeman
Livingston
Ashland
Camp Crook
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone

Cumulative Mountain Pine Beetle-Caused Mortality during the 1971-1989 Outbreak Event in Montana and Northern Idaho

Disclaimer

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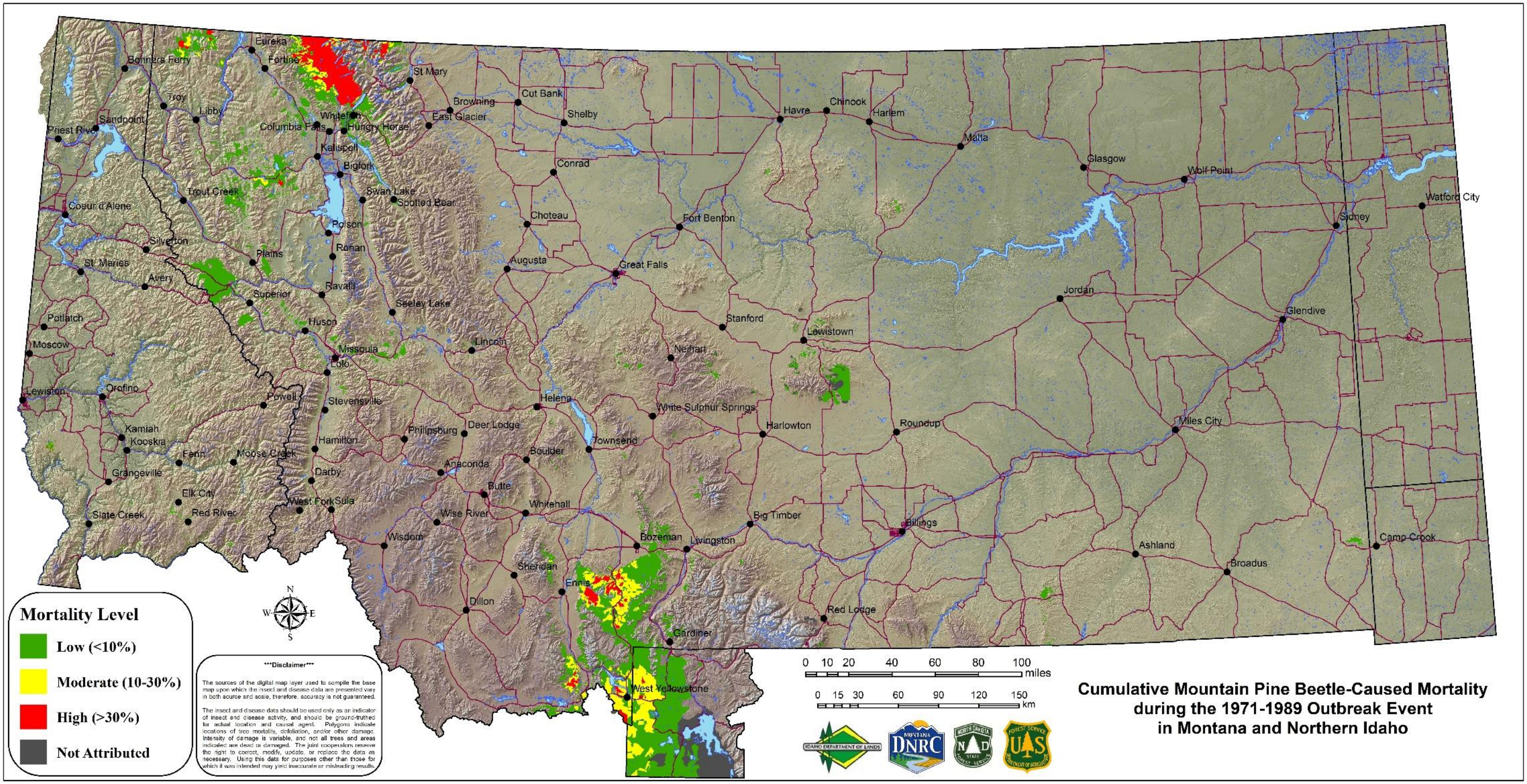
1971–1981: Cumulative mountain pine beetle-caused mortality estimated by ADS


Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE
Eureka
Bonners Ferry
Fortine
St Mary
Troy
Libby
Cut Bank
Browning
East Glacier
Shelby
Havre
Chinook
Harlem
Malta
Sandpoint
Priest River
Columbia Falls
Whitefish
Hungry Horse
Kalispell
Bigfork
Conrad
Glasgow
Wolf Point
Watford City
Trout Creek
Swan Lake
Spotted Bear
Coeur d'Alene
Polson
Choteau
Fort Benton
Sidney
Silverton
Ronan
Plains
St. Maries
Augusta
Great Falls
Avery
Ravalli
Superior
Jordan
Seeley Lake
Glendive
Potlatch
Huson
Stanford
Lewistown
Moscow
Lincoln
Missoula
Neihart
Lolo
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Miles City
Kamiah
Kooskia
Hamilton
Philipsburg
Deer Lodge
Harlowton
Roundup
Fenn
Moose Creek
Boulder
Townsend
Grangeville
Darby
Anaconda
Elk City
Butte
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
Big Timber
Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone

Disclaimer

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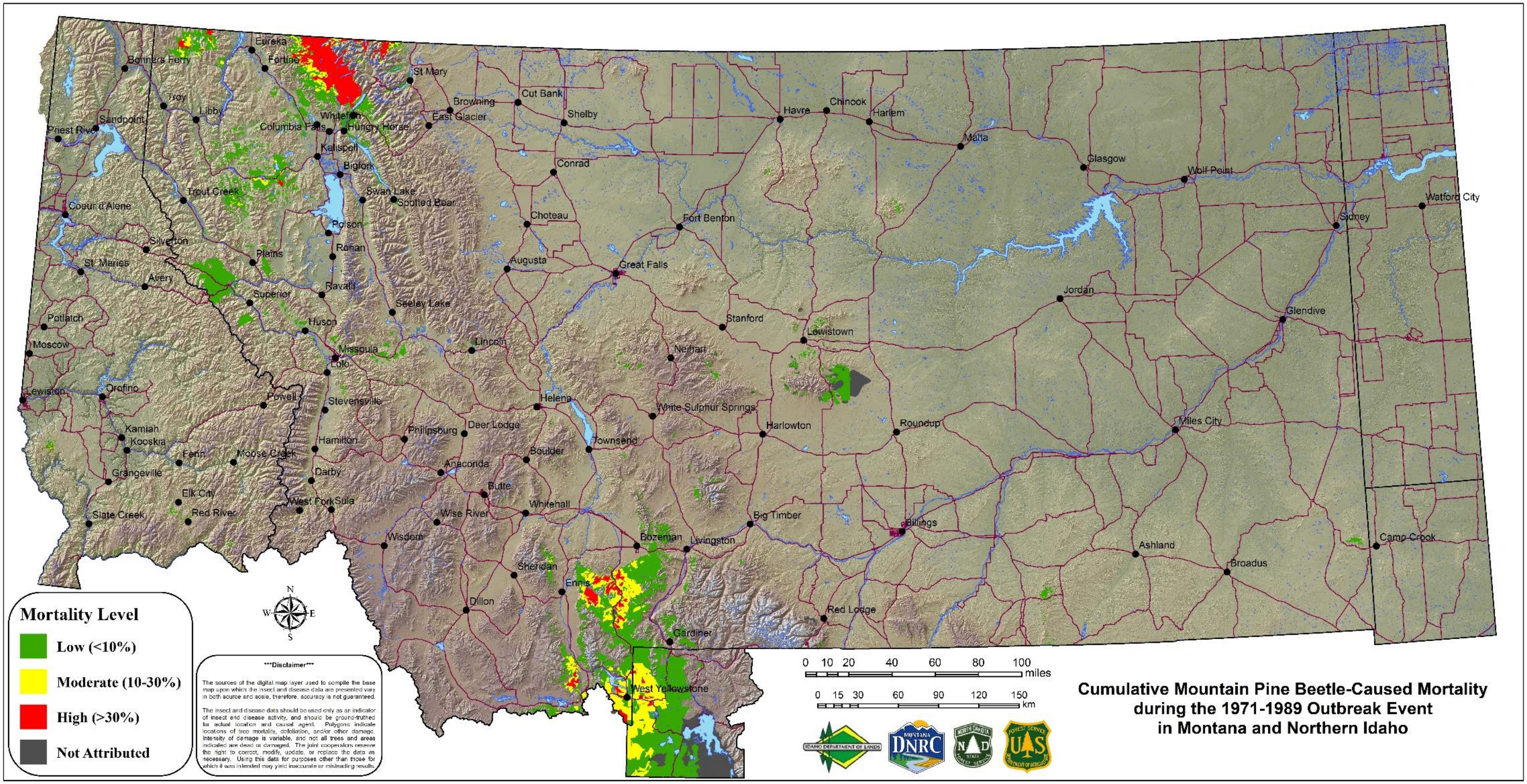
1971–1982: Cumulative mountain pine beetle-caused mortality estimated by ADS


Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA STATE FOREST SERVICE
FOREST SERVICE
Eureka
Fortine
Bonners Ferry
Troy
Libby
St Mary
Browning
Cut Bank
East Glacier
Shelby
Havre
Chinook
Harlem
Malta
Glasgow
Wolf Point
Watford City
Sidney
Priest River
Sandpoint
Whitefish
Columbia Falls
Hungry Horse
Kalispell
Bigfork
Conrad
Trout Creek
Swan Lake
Spotted Bear
Coeur d'Alene
Choteau
Fort Benton
Polson
Ronan
Silverton
St. Maries
Plains
Augusta
Great Falls
Avery
Ravalli
Superior
Jordan
Seeley Lake
Glendive
Potlatch
Huson
Stanford
Lewistown
Moscow
Missoula
Lincoln
Neihart
Lolo
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Kamiah
Kooskia
Hamilton
Philipsburg
Deer Lodge
Harlowton
Roundup
Miles City
Townsend
Fenn
Moose Creek
Boulder
Grangeville
Darby
Anaconda
Butte
Elk City
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
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Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone

Disclaimer

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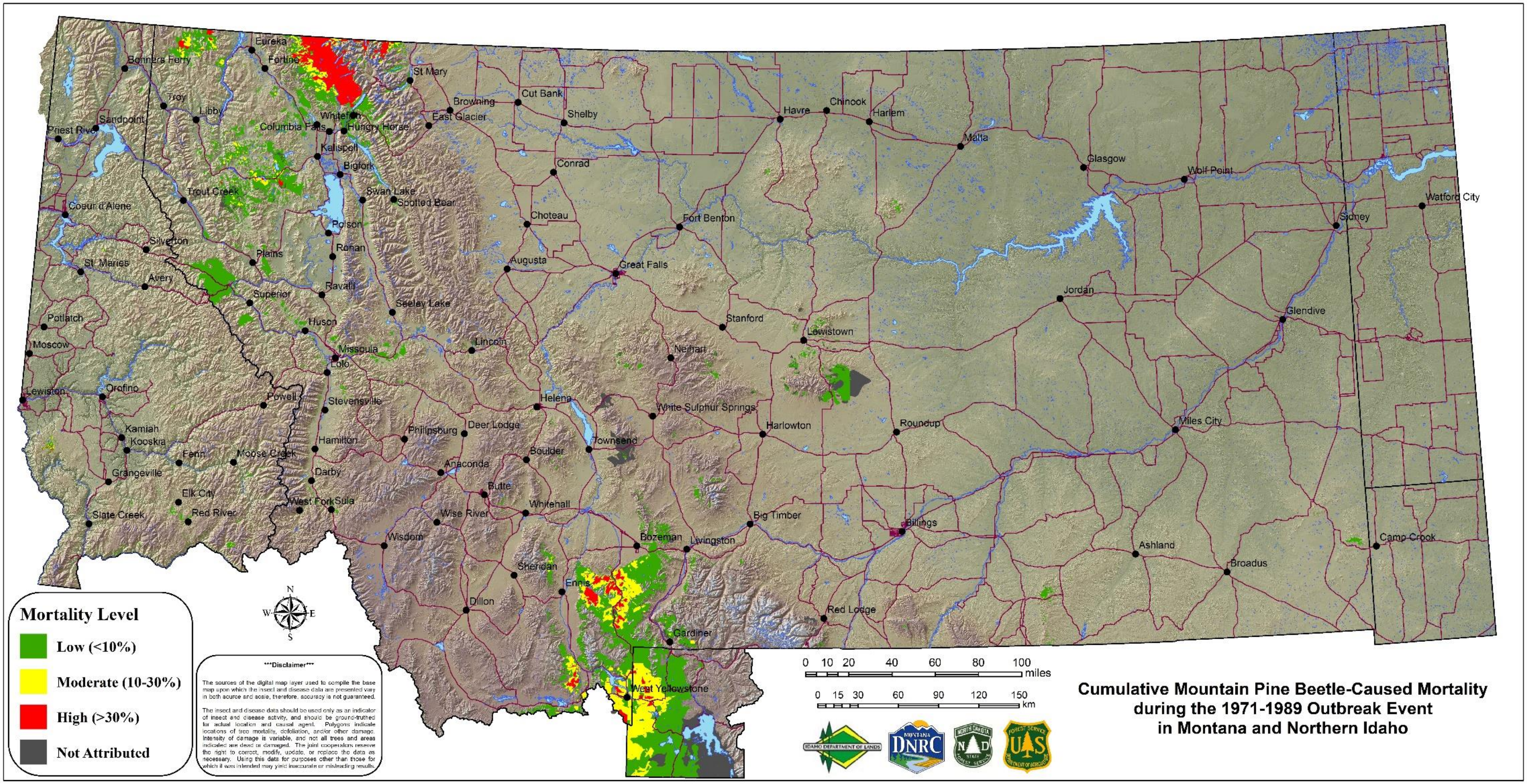
1971–1983: Cumulative mountain pine beetle-caused mortality estimated by ADS


Eureka
Bonners Ferry
Fortine
St Mary
Troy
Browning
Cut Bank
Libby
Whitefish
East Glacier
Shelby
Havre
Chinook
Harlem
Sandpoint
Priest River
Columbia Falls
Hungry Horse
Kalispell
Malta
Bigfork
Conrad
Glasgow
Wolf Point
Trout Creek
Swan Lake
Spotted Bear
Watford City
Coeur d'Alene
Choteau
Fort Benton
Sidney
Polson
Silverton
Ronan
Plains
Augusta
Great Falls
St. Maries
Avery
Ravalli
Jordan
Superior
Seeley Lake
Glendive
Potlatch
Huson
Stanford
Lewistown
Moscow
Missoula
Lincoln
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Powell
Helena
Stevensville
White Sulphur Springs
Harlowton
Roundup
Kamiah
Deer Lodge
Miles City
Kooskia
Philipsburg
Hamilton
Townsend
Fenn
Moose Creek
Boulder
Anaconda
Grangeville
Darby
Butte
Elk City
West Fork
Sula
Whitehall
Big Timber
Slate Creek
Red River
Wise River
Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Broadus
Sheridan
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone
N
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0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Mortality Level

- 🟩 Low (<10%)
- 🟨 Moderate (10-30%)
- 🟥 High (>30%)
- ⬛ Not Attributed

Disclaimer

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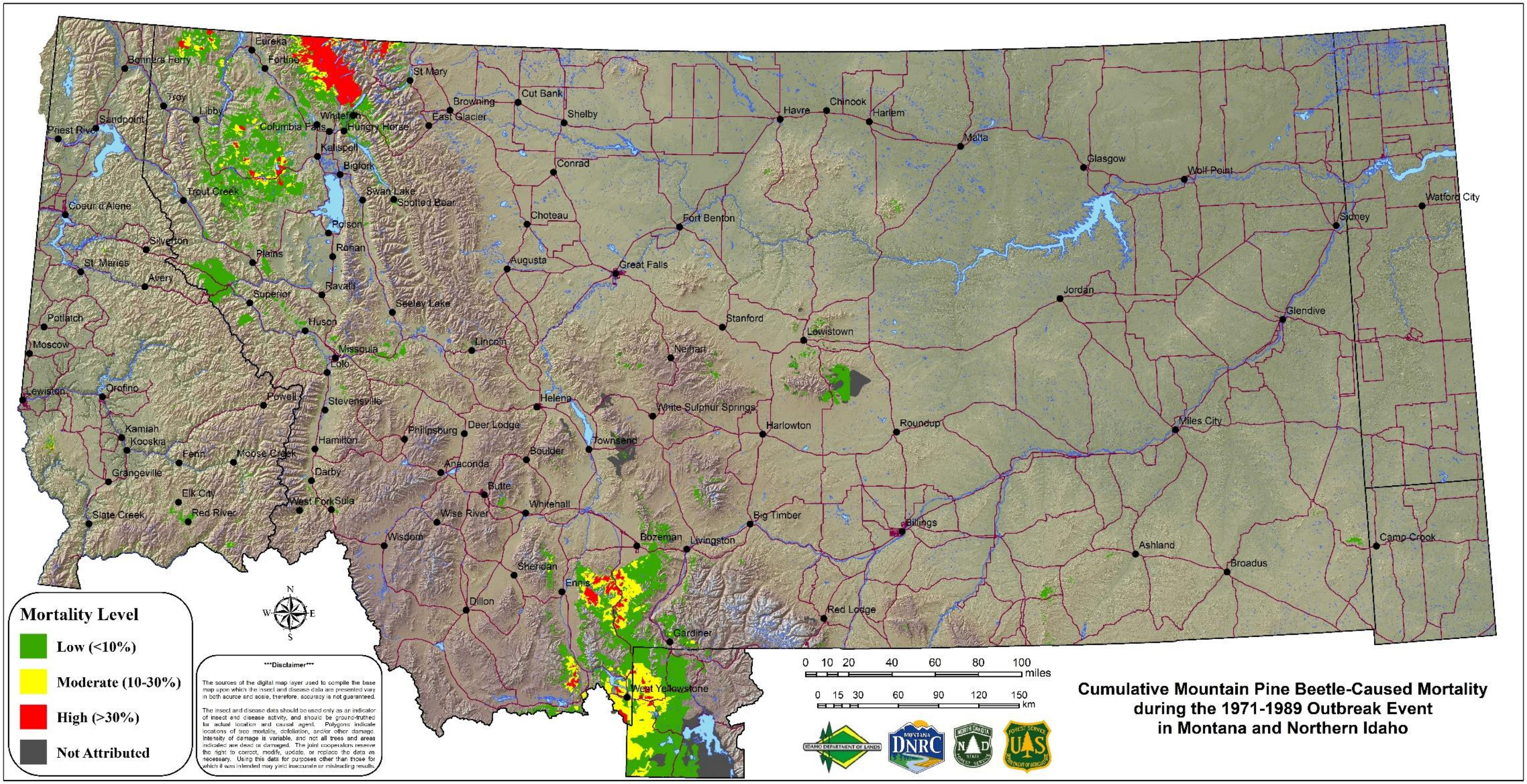
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

1971–1984: Cumulative mountain pine beetle-caused mortality estimated by ADS


Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE
Eureka
Fortine
Bonners Ferry
Troy
Libby
Sandpoint
Priest River
Columbia Falls
Whitefish
Hungry Horse
Kalispell
Bigfork
St Mary
Browning
East Glacier
Cut Bank
Shelby
Havre
Chinook
Harlem
Malta
Glasgow
Wolf Point
Watford City
Sidney
Conrad
Choteau
Fort Benton
Trout Creek
Swan Lake
Spotted Bear
Coeur d'Alene
Polson
Ronan
Silverton
St. Maries
Plains
Avery
Augusta
Great Falls
Ravalli
Superior
Seeley Lake
Jordan
Glendive
Potlatch
Huson
Stanford
Lewistown
Moscow
Missoula
Lolo
Lincoln
Neihart
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Harlowton
Roundup
Miles City
Kamiah
Kooskia
Hamilton
Philipsburg
Deer Lodge
Townsend
Fenn
Moose Creek
Boulder
Anaconda
Grangeville
Darby
Butte
Elk City
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
Big Timber
Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone

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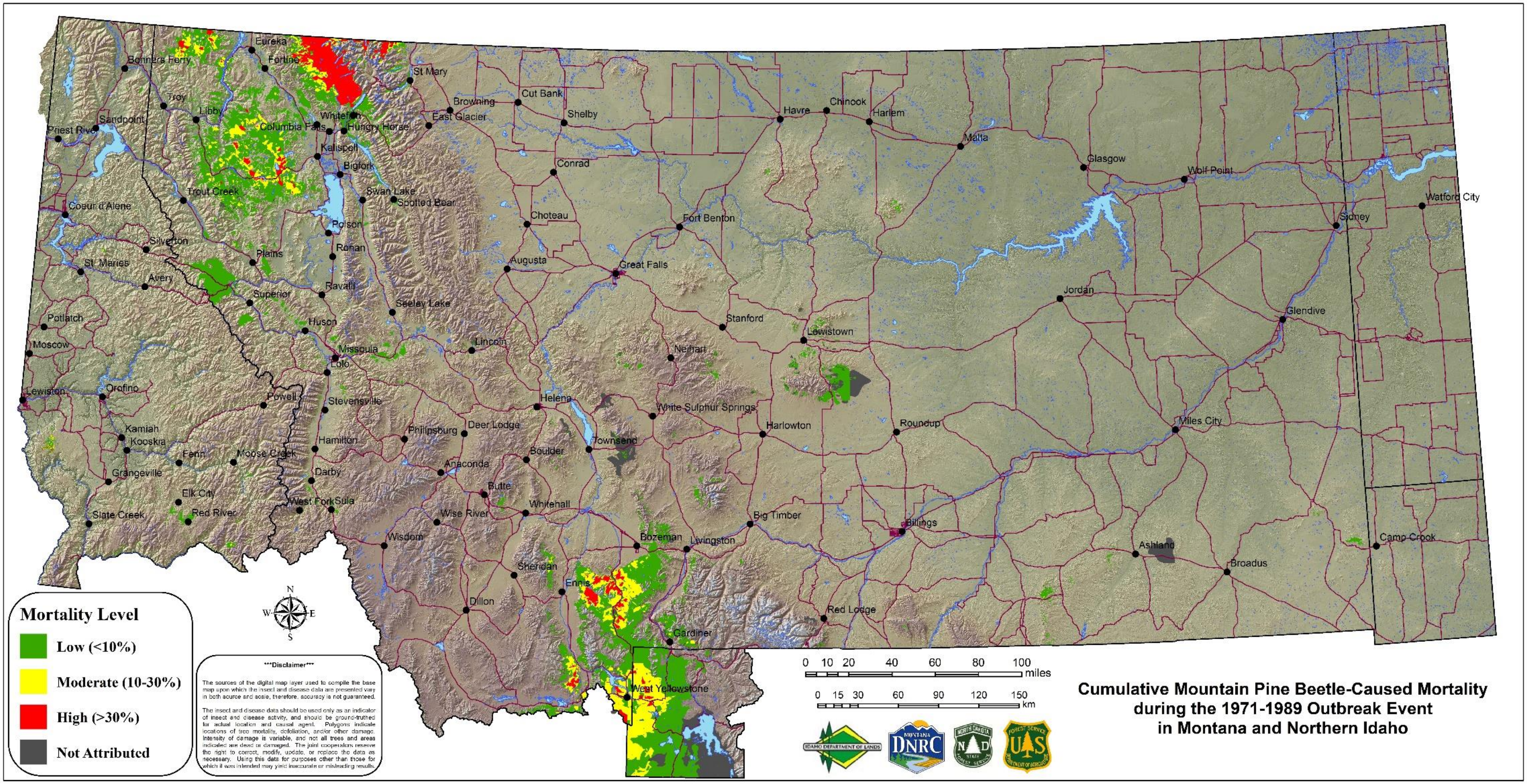
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

1971–1985: Cumulative mountain pine beetle-caused mortality estimated by ADS



Mortality Level

🟩 Low (<10%)

🟨 Moderate (10-30%)

🟥 High (>30%)

⬛ Not Attributed

Disclaimer

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Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

N
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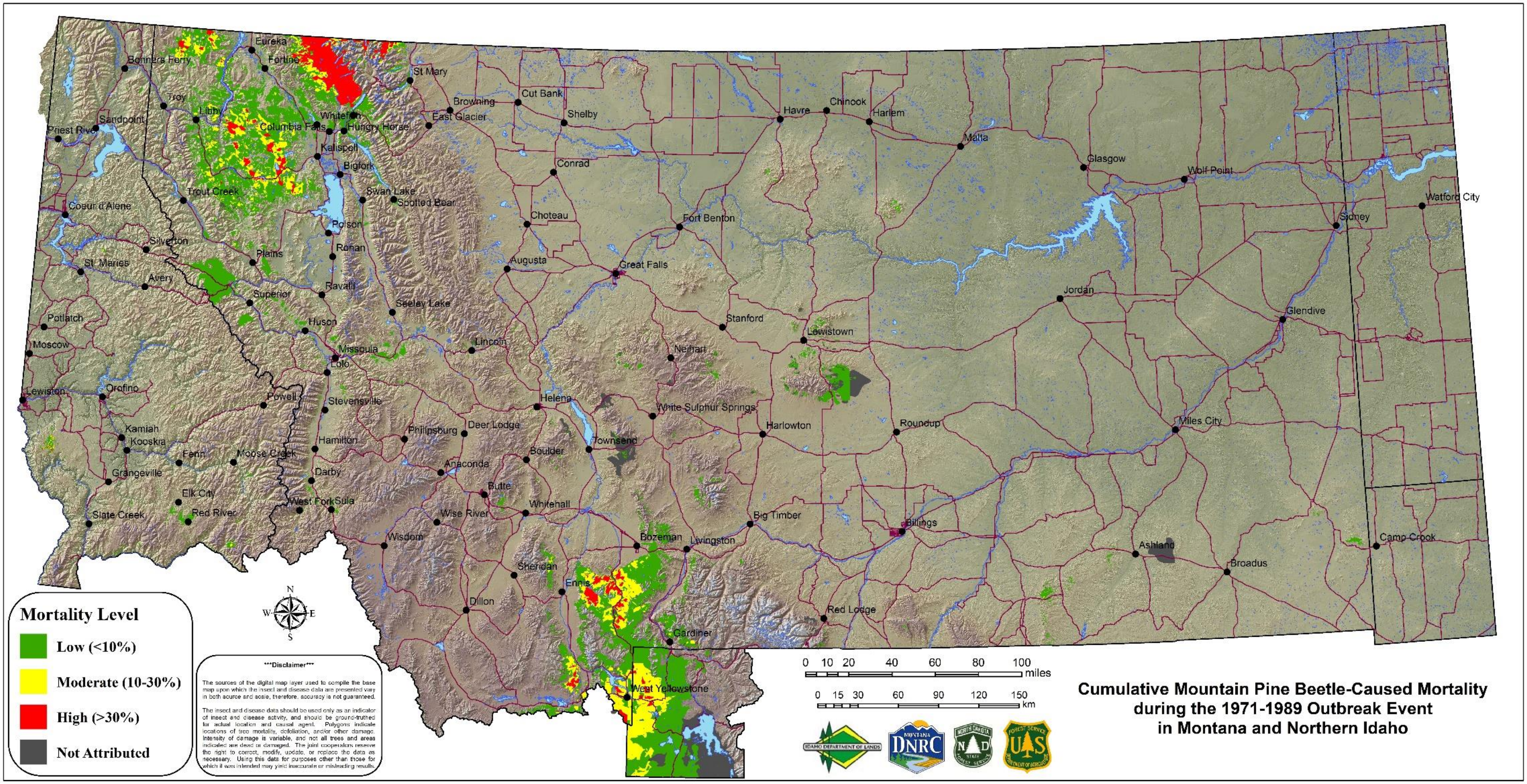
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE
Eureka
Fortine
Bonners Ferry
St Mary
Troy
Libby
Browning
Cut Bank
East Glacier
Shelby
Havre
Chinook
Harlem
Malta
Priest River
Sandpoint
Whitefish
Columbia Falls
Hungry Horse
Kalispell
Bigfork
Conrad
Glasgow
Wolf Point
Trout Creek
Swan Lake
Spotted Bear
Watford City
Coeur d'Alene
Choteau
Fort Benton
Sidney
Polson
Silverton
Ronan
Plains
Augusta
Great Falls
St. Maries
Avery
Ravalli
Jordan
Superior
Seeley Lake
Glendive
Potlatch
Huson
Stanford
Lewistown
Moscow
Lincoln
Missoula
Neihart
Lolo
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Kamiah
Kooskia
Philipsburg
Deer Lodge
Harlowton
Roundup
Miles City
Hamilton
Townsend
Fenn
Moose Creek
Boulder
Grangeville
Anaconda
Darby
Butte
Elk City
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
Big Timber
Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone

1971–1986: Cumulative mountain pine beetle-caused mortality estimated by ADS


Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE
Eureka
Fortine
Bonners Ferry
Troy
Libby
Sandpoint
Priest River
St Mary
Browning
Cut Bank
East Glacier
Shelby
Whitefish
Columbia Falls
Hungry Horse
Kalispell
Bigfork
Havre
Chinook
Harlem
Malta
Glasgow
Wolf Point
Watford City
Conrad
Trout Creek
Swan Lake
Spotted Bear
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Polson
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Great Falls
St. Maries
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Avery
Ravalli
Superior
Seeley Lake
Jordan
Glendive
Potlatch
Huson
Stanford
Lewistown
Moscow
Missoula
Lincoln
Neihart
Lolo
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Harlowton
Roundup
Miles City
Kamiah
Kooskia
Philipsburg
Deer Lodge
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Townsend
Fenn
Moose Creek
Boulder
Anaconda
Grangeville
Darby
Butte
Elk City
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
Big Timber
Billings
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Red Lodge
Gardiner
West Yellowstone

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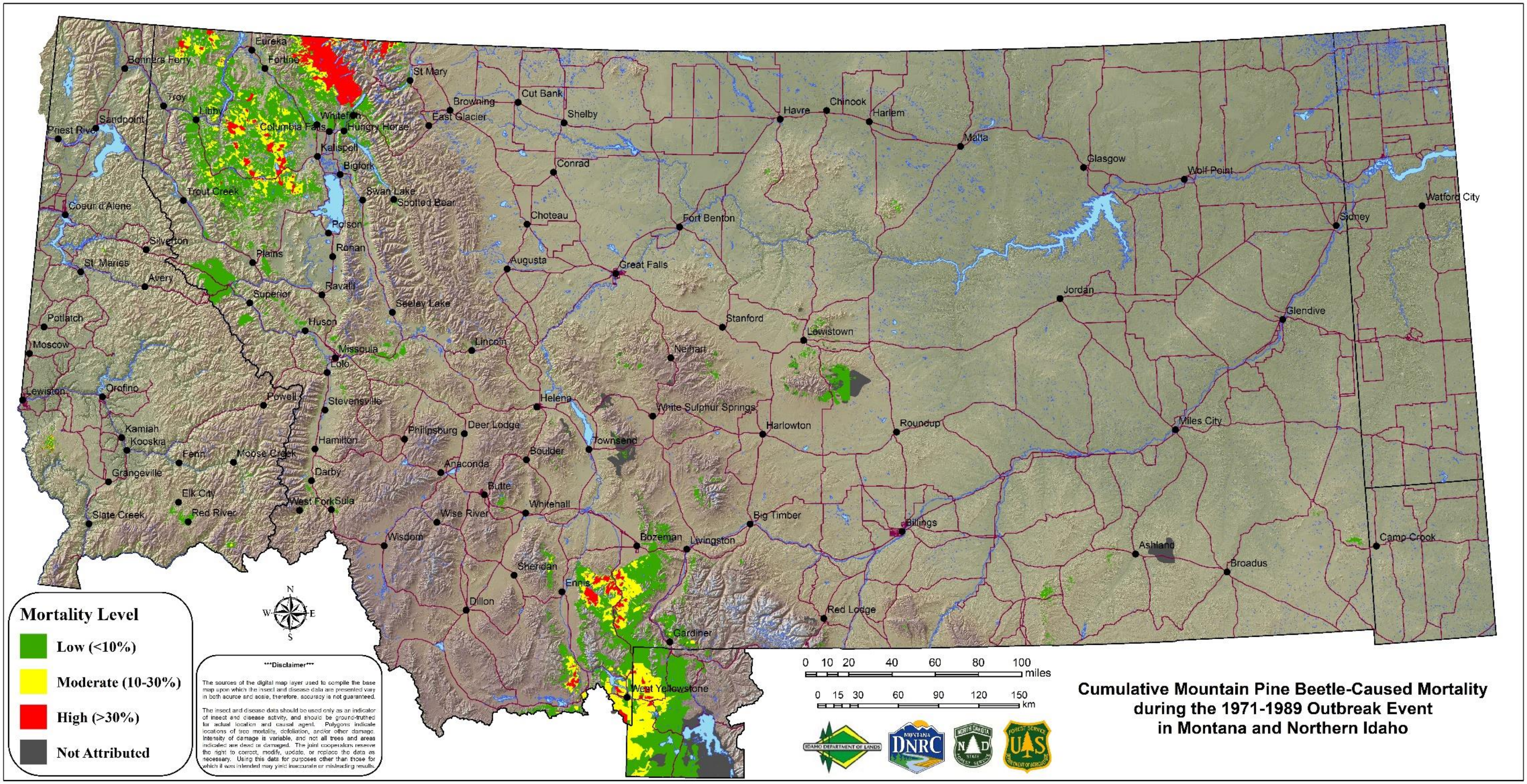
1971–1987: Cumulative mountain pine beetle-caused mortality estimated by ADS


Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
Eureka
Bonners Ferry
Fortine
St Mary
Troy
Browning
Cut Bank
Libby
Whitefish
East Glacier
Shelby
Havre
Chinook
Harlem
Sandpoint
Priest River
Columbia Falls
Hungry Horse
Kalispell
Malta
Bigfork
Conrad
Glasgow
Wolf Point
Trout Creek
Swan Lake
Spotted Bear
Watford City
Coeur d'Alene
Polson
Choteau
Fort Benton
Sidney
Silverton
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Ravalli
Superior
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Huson
Stanford
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Moscow
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Orofino
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Stevensville
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Kooskia
Philipsburg
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Roundup
Miles City
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Fenn
Moose Creek
Boulder
Grangeville
Darby
Anaconda
Elk City
West Fork
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Butte
Whitehall
Slate Creek
Red River
Wise River
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Billings
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Bozeman
Livingston
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Sheridan
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Ennis
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Gardiner
West Yellowstone

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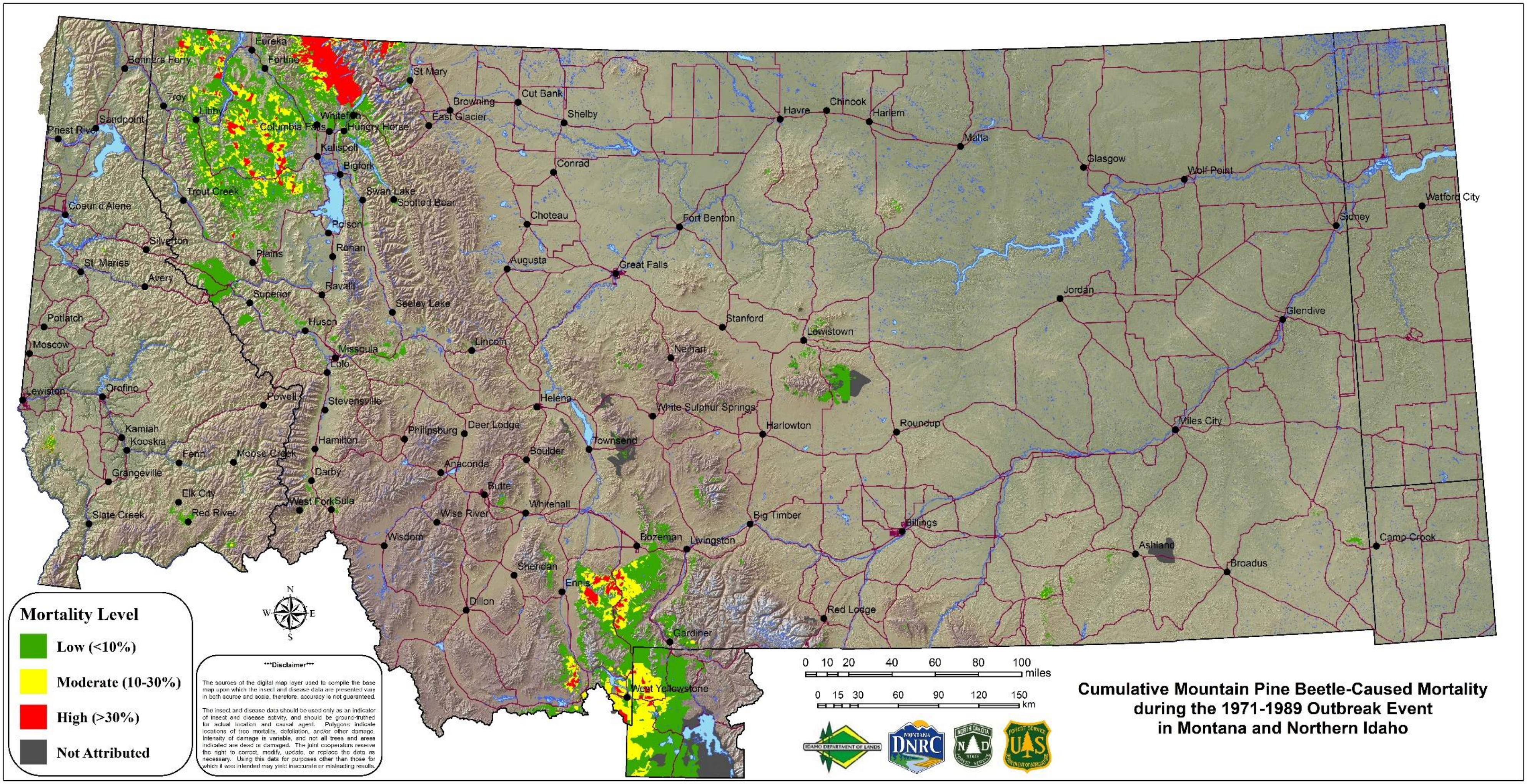
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

1971–1988: Cumulative mountain pine beetle-caused mortality estimated by ADS


Eureka
Bonners Ferry
Fortine
St Mary
Troy
Browning
Cut Bank
Libby
Sandpoint
Priest River
Whitefish
Columbia Falls
Hungry Horse
East Glacier
Shelby
Havre
Chinook
Harlem
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Kalispell
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Conrad
Glasgow
Wolf Point
Trout Creek
Swan Lake
Spotted Bear
Watford City
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Choteau
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St. Maries
Avery
Ravalli
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Superior
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Huson
Stanford
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Missoula
Neihart
Lolo
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Miles City
Kamiah
Kooskia
Philipsburg
Deer Lodge
Harlowton
Roundup
Hamilton
Townsend
Fenn
Moose Creek
Boulder
Anaconda
Grangeville
Darby
Butte
Elk City
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
Big Timber
Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone
N
W
E
S
Mortality Level
Low (<10%)
Moderate (10-30%)
High (>30%)
Not Attributed
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km

Disclaimer

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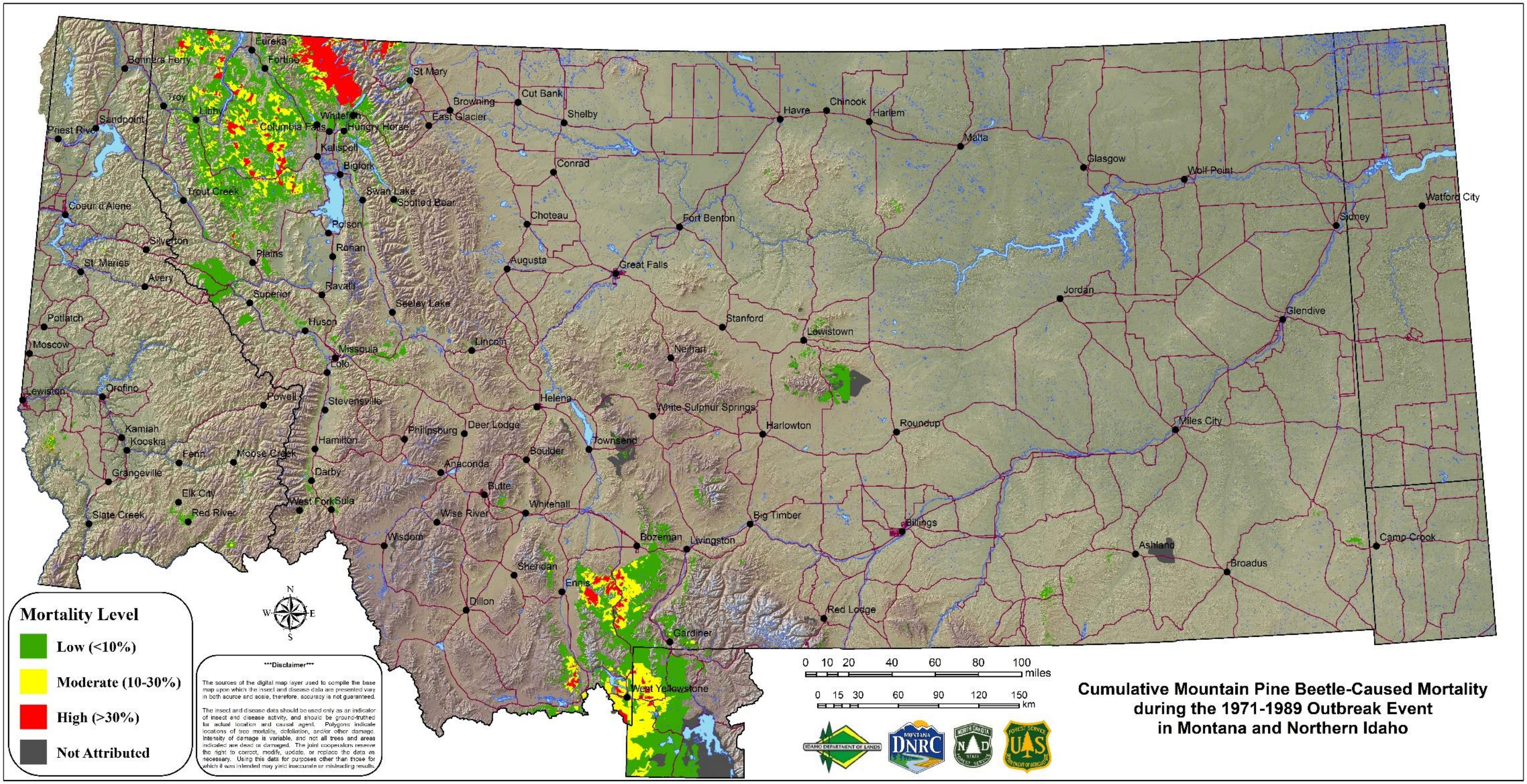
**Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho**

1971–1989: Cumulative mountain pine beetle-caused mortality estimated by ADS


Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
N
W
E
S
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
Cumulative Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
Eureka
Fortine
Bonners Ferry
St Mary
Troy
Cut Bank
Browning
Libby
East Glacier
Shelby
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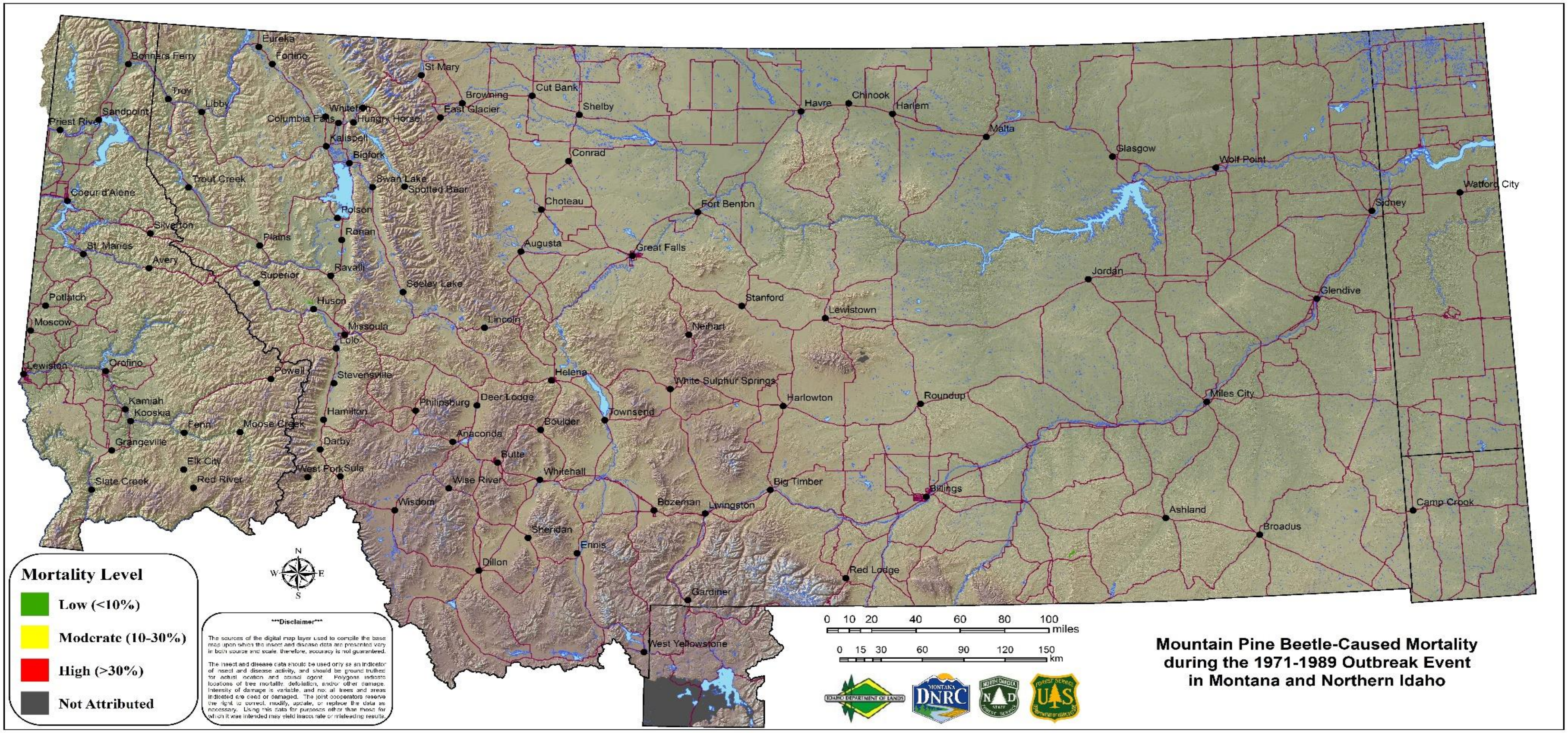
Appendix 2: Maps showing annual MPB-caused mortality area during each year of the 1971–1989 outbreak event (total 6.1 million acres) classified by severity of mortality estimated through aerial detection surveys.

1971: Annual mountain pine beetle-caused mortality estimated by ADS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Broadus
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Dillon
Red Lodge
Gardiner
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Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
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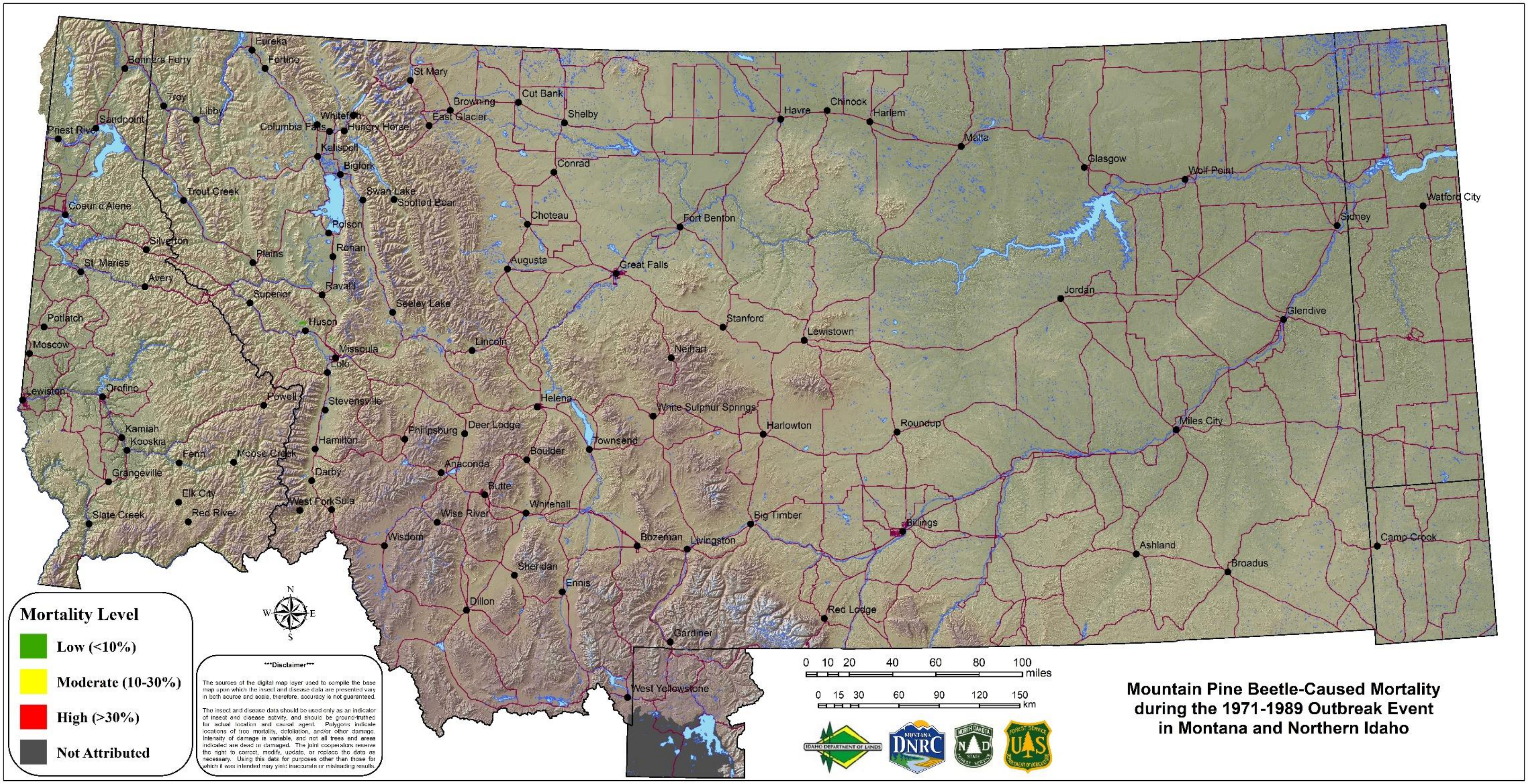
1972: Annual mountain pine beetle-caused mortality estimated by ADS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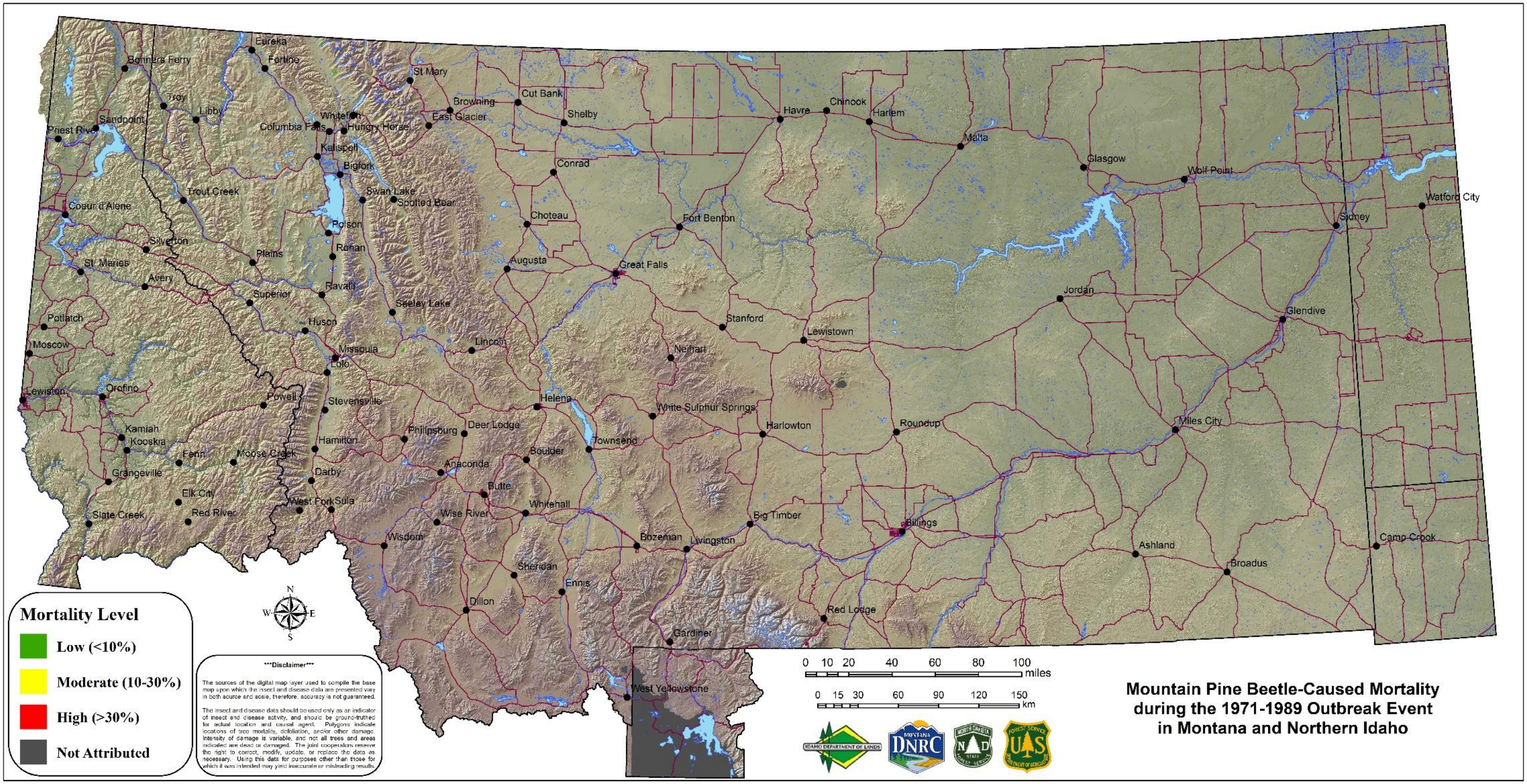
Mountain Pine Beetle-Caused Mortality during the 1971-1989 Outbreak Event in Montana and Northern Idaho

1973: Annual mountain pine beetle-caused mortality estimated by ADS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Mortality Level

- 🟩 Low (<10%)
- 🟨 Moderate (10-30%)
- 🟥 High (>30%)
- ■ Not Attributed

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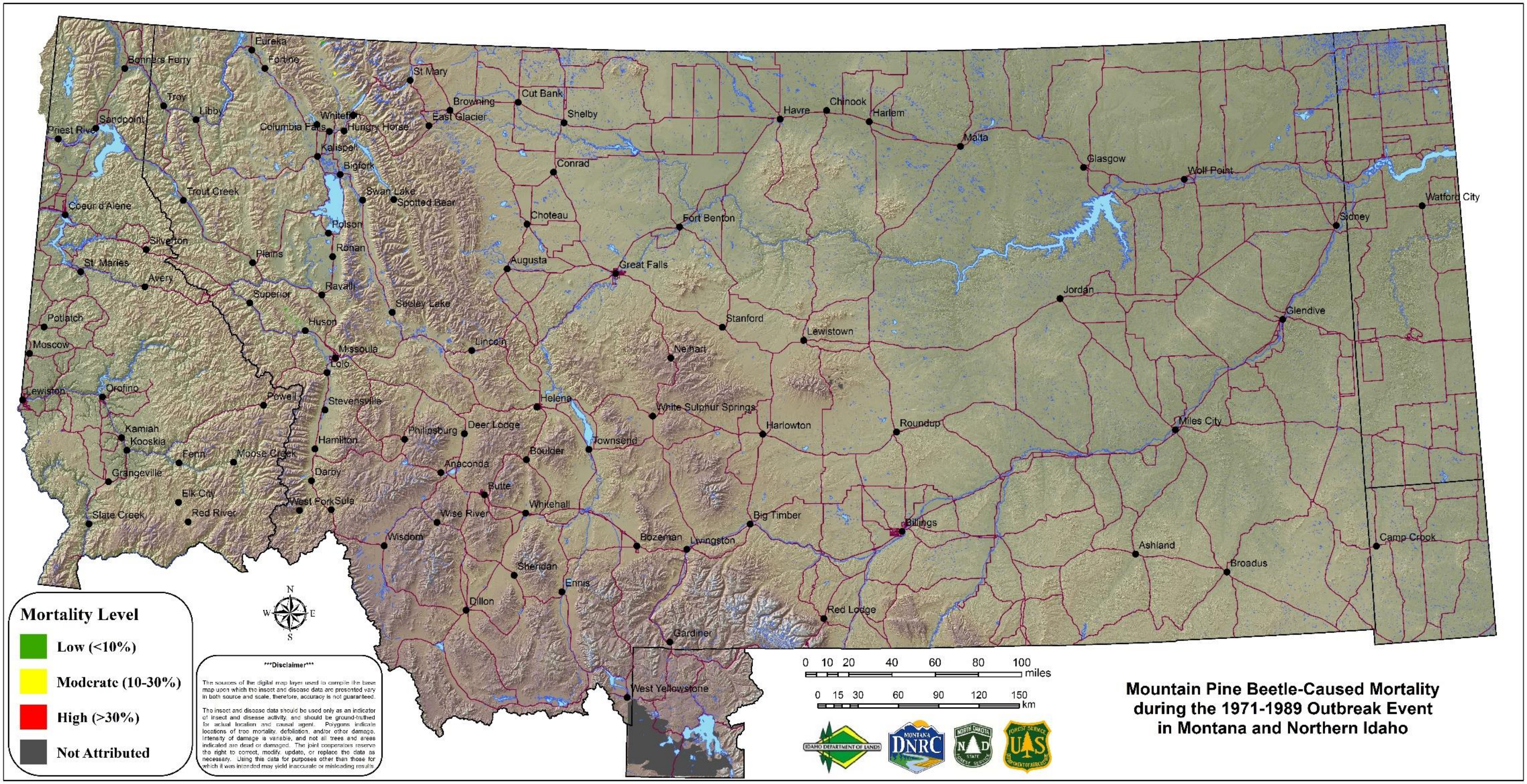
1974: Annual mountain pine beetle-caused mortality estimated by ADS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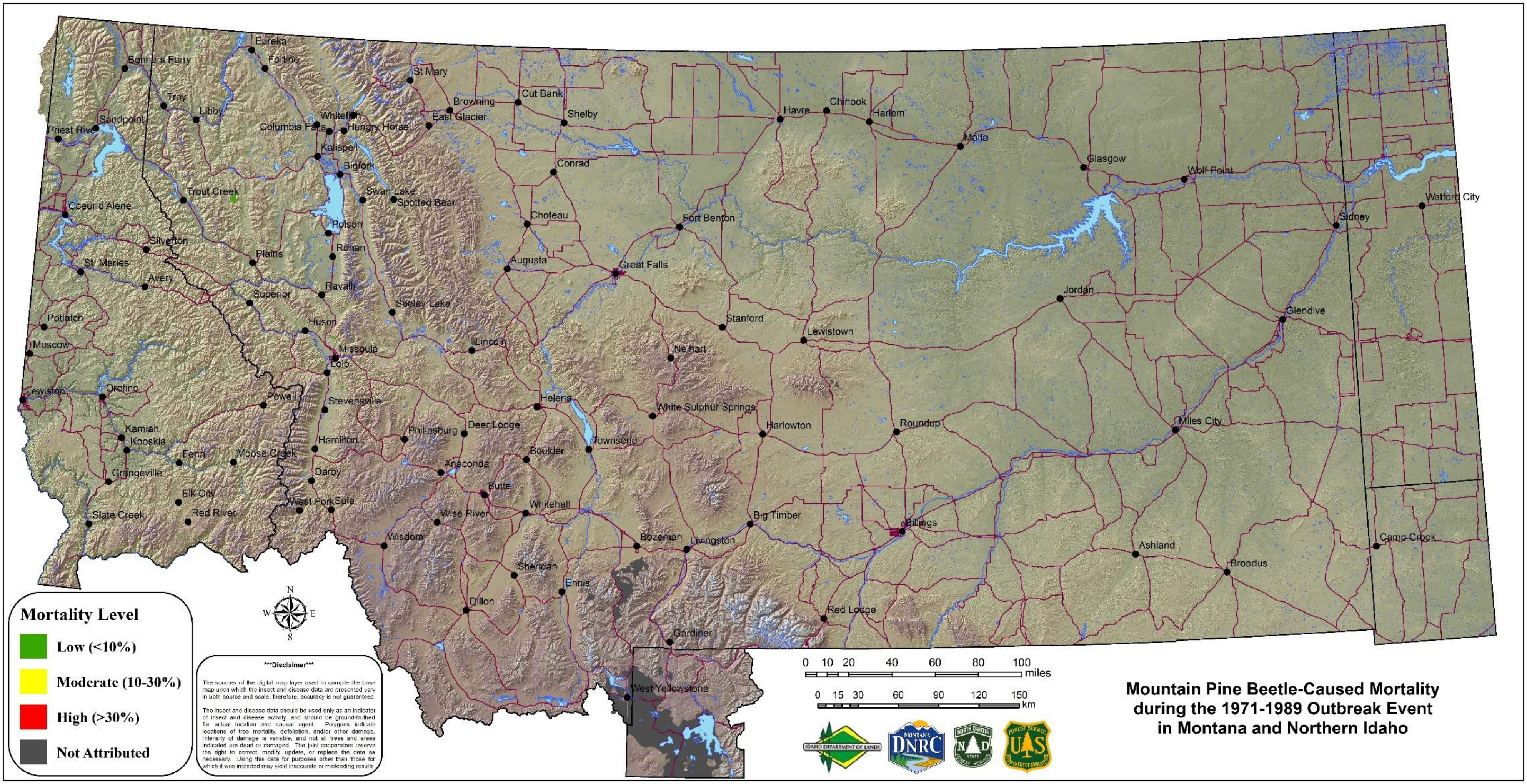
1975: Annual mountain pine beetle-caused mortality estimated by ADS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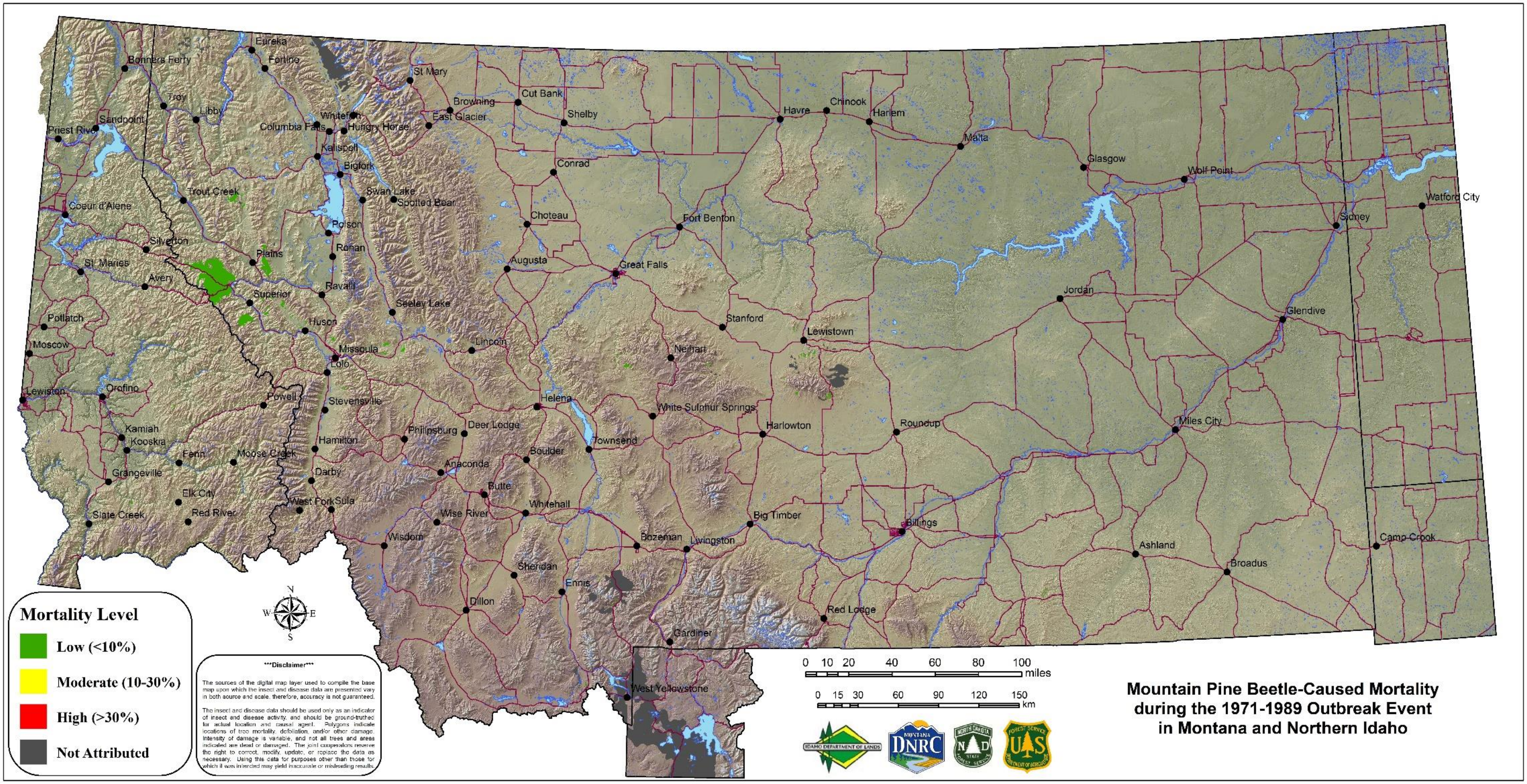
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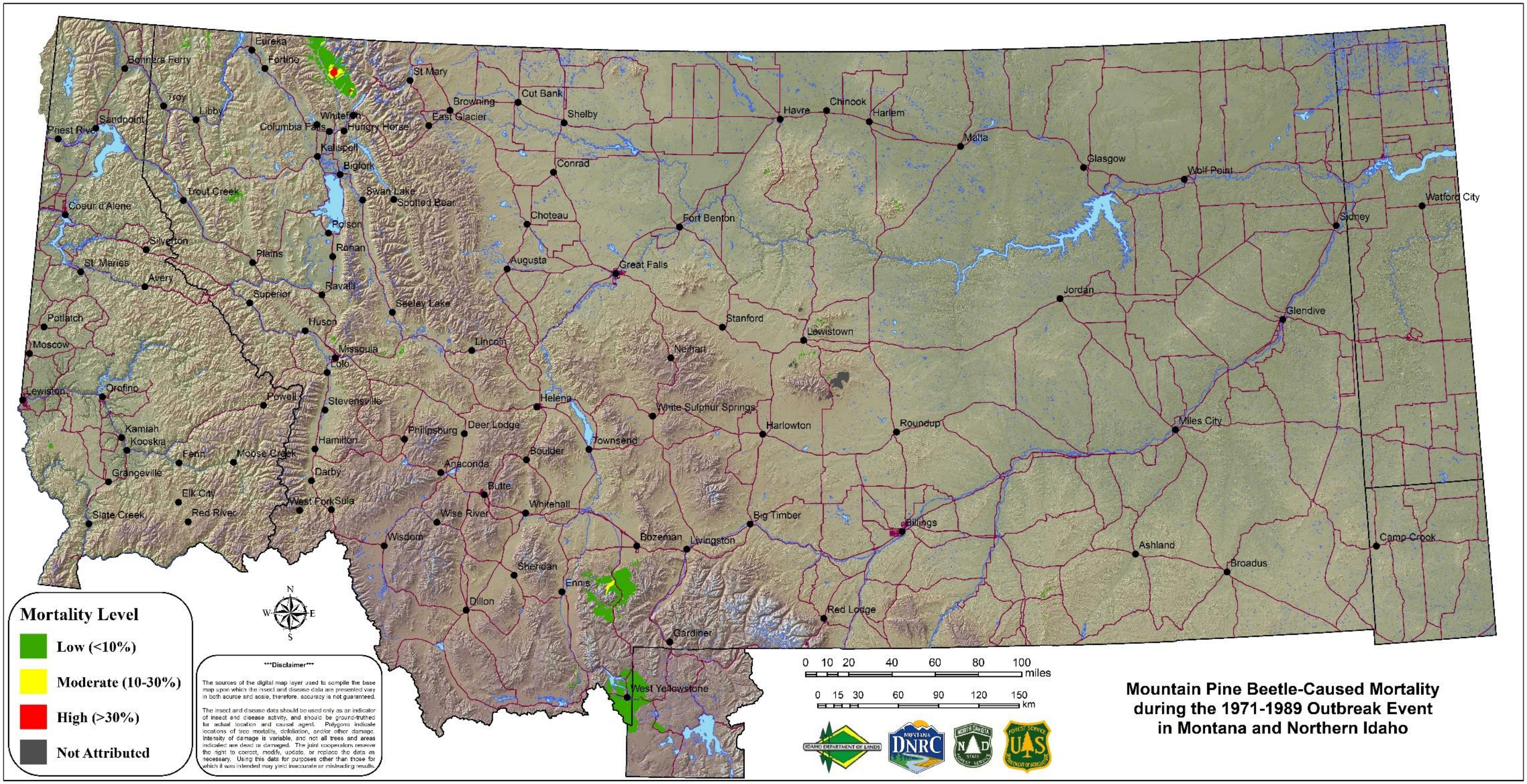
1977: Annual mountain pine beetle-caused mortality estimated by ADS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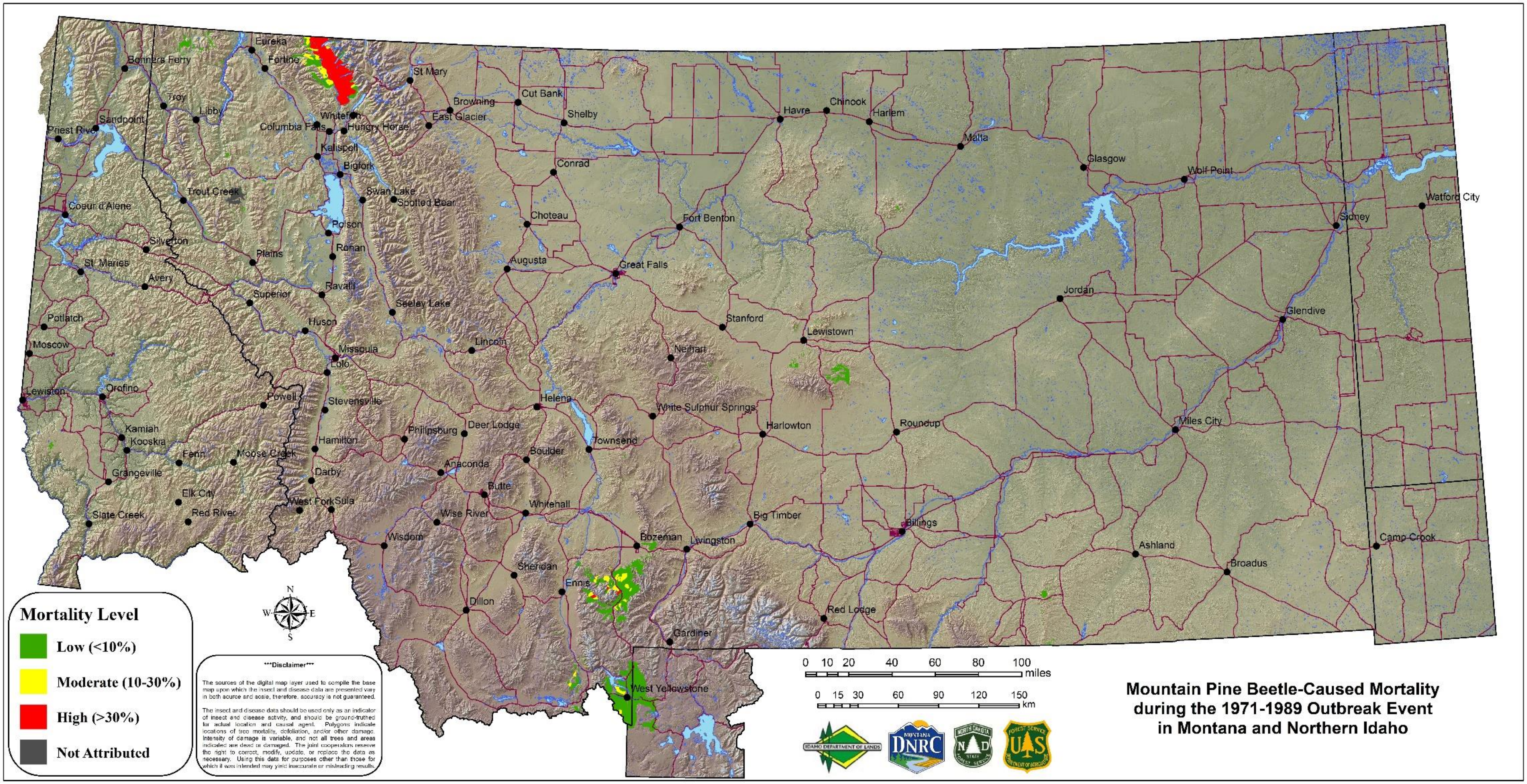
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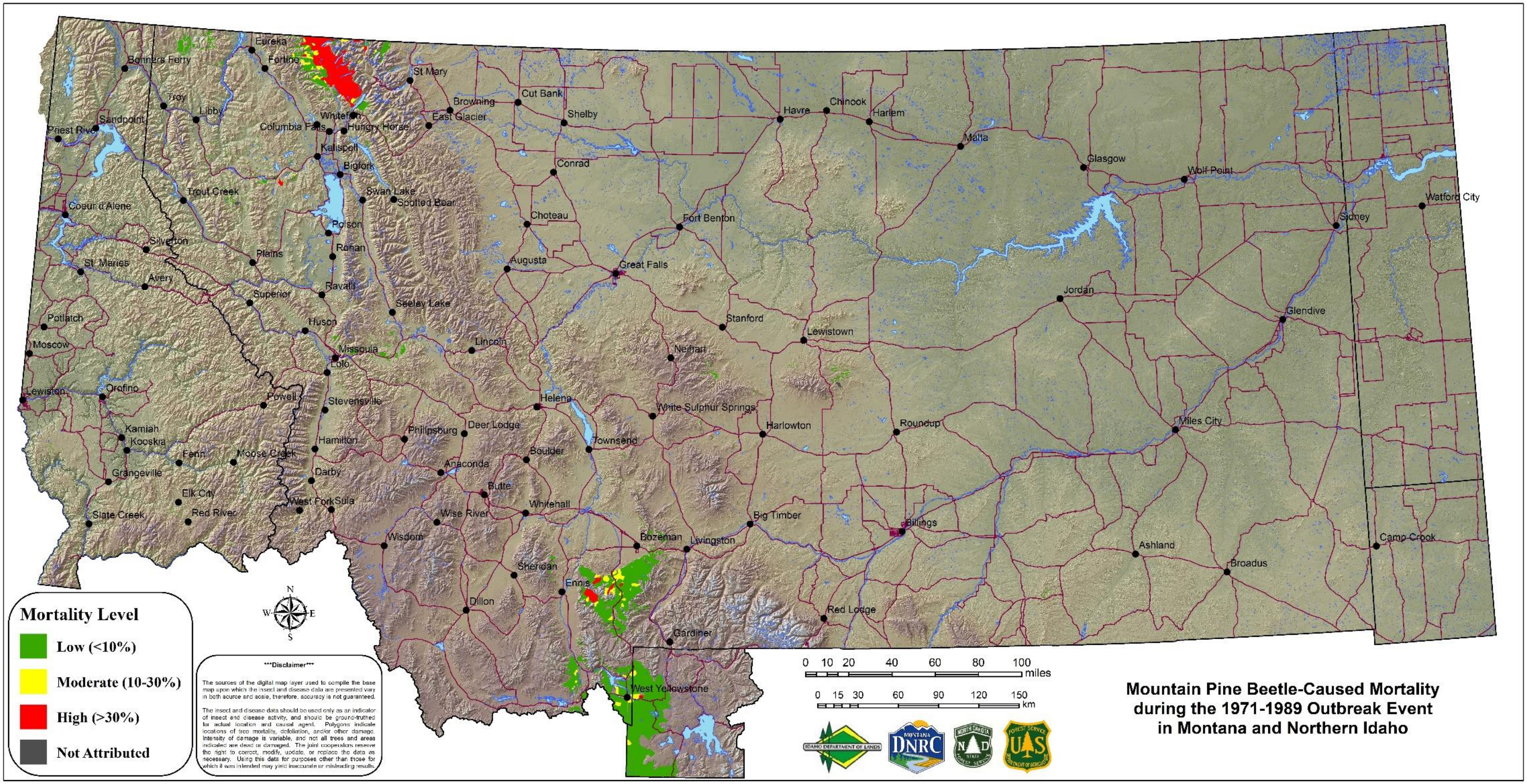
1979: Annual mountain pine beetle-caused mortality estimated by ADS



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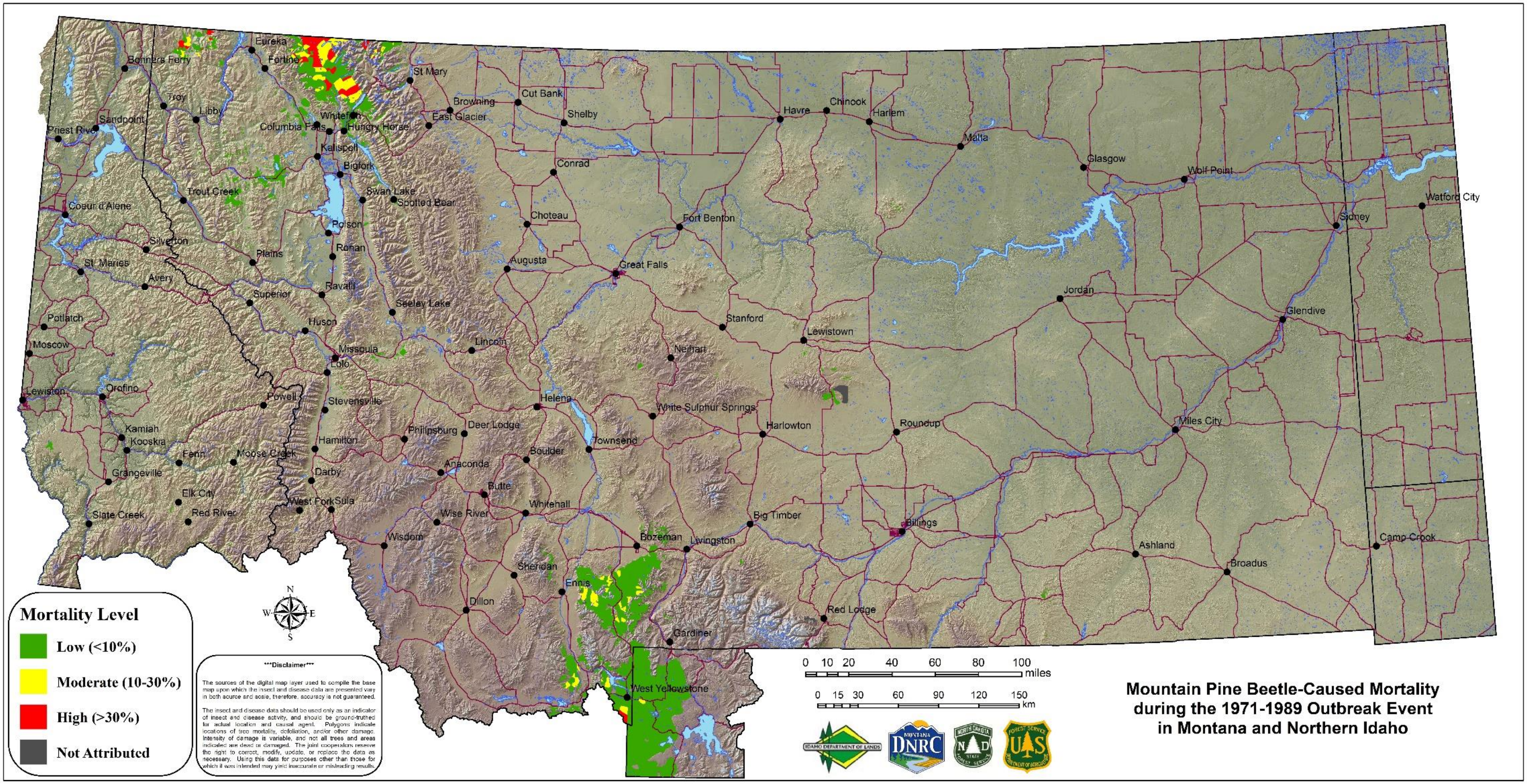
Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

1980: Annual mountain pine beetle-caused mortality estimated by ADS


Eureka
Fortine
Bonners Ferry
St Mary
Troy
Libby
Browning
Cut Bank
Shelby
Havre
Chinook
Harlem
Sandpoint
Priest River
Columbia Falls
Whitefish
Hungry Horse
East Glacier
Kalispell
Malta
Bigfork
Conrad
Glasgow
Wolf Point
Trout Creek
Swan Lake
Spotted Bear
Coeur d'Alene
Watford City
Polson
Choteau
Fort Benton
Sidney
Silverton
Ronan
Plains
St. Maries
Augusta
Great Falls
Avery
Ravalli
Superior
Jordan
Seeley Lake
Potlatch
Huson
Stanford
Glendive
Lewistown
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Grangeville
Darby
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Slate Creek
Red River
Wise River
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IDAHO DEPARTMENT OF LANDS
MONTANA DNRC
NORTH DAKOTA N D STATE FOREST SERVICE
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Mortality Level

🟩 Low (<10%)

🟨 Moderate (10-30%)

🟥 High (>30%)

⬛ Not Attributed

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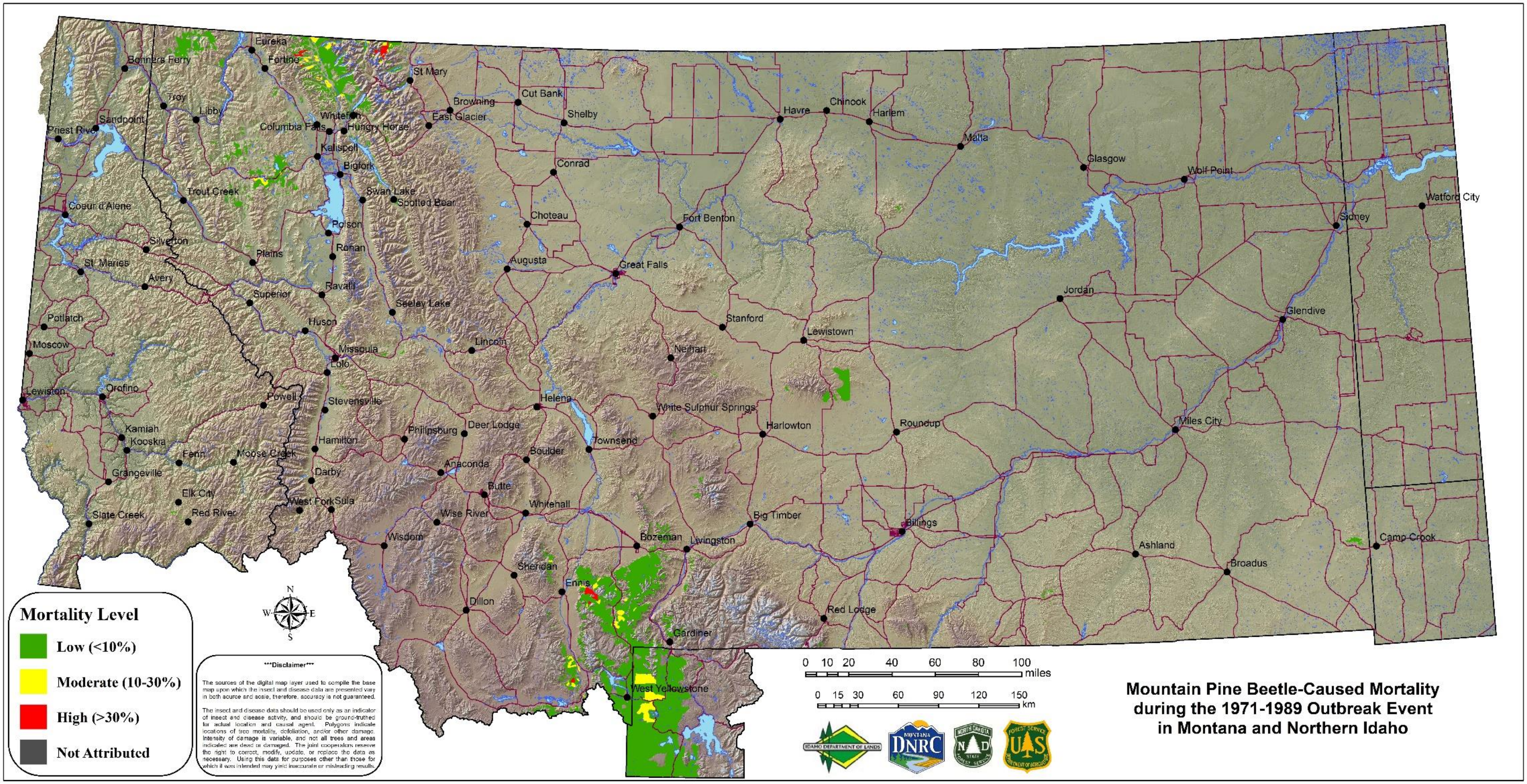
Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho

1981: Annual mountain pine beetle-caused mortality estimated by ADS


Eureka
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IDAHO DEPARTMENT OF LANDS
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FOREST SERVICE

Mortality Level

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- 🟨 Moderate (10-30%)
- 🟥 High (>30%)
- ⬛ Not Attributed

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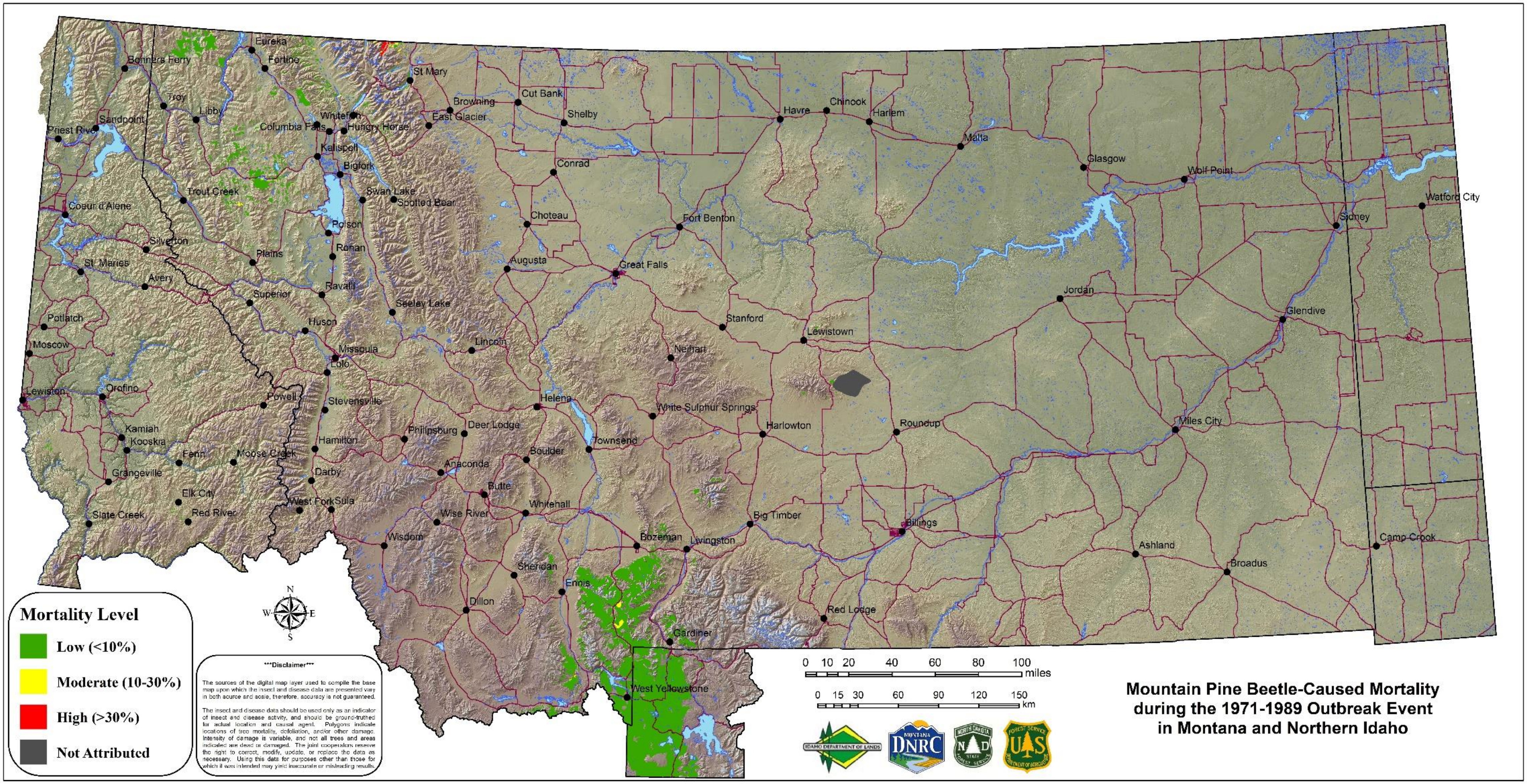
Mountain Pine Beetle-Caused Mortality during the 1971-1989 Outbreak Event in Montana and Northern Idaho

1982: Annual mountain pine beetle-caused mortality estimated by ADS


Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho
Mortality Level
🟩 Low (<10%)
🟨 Moderate (10-30%)
🟥 High (>30%)
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Eureka
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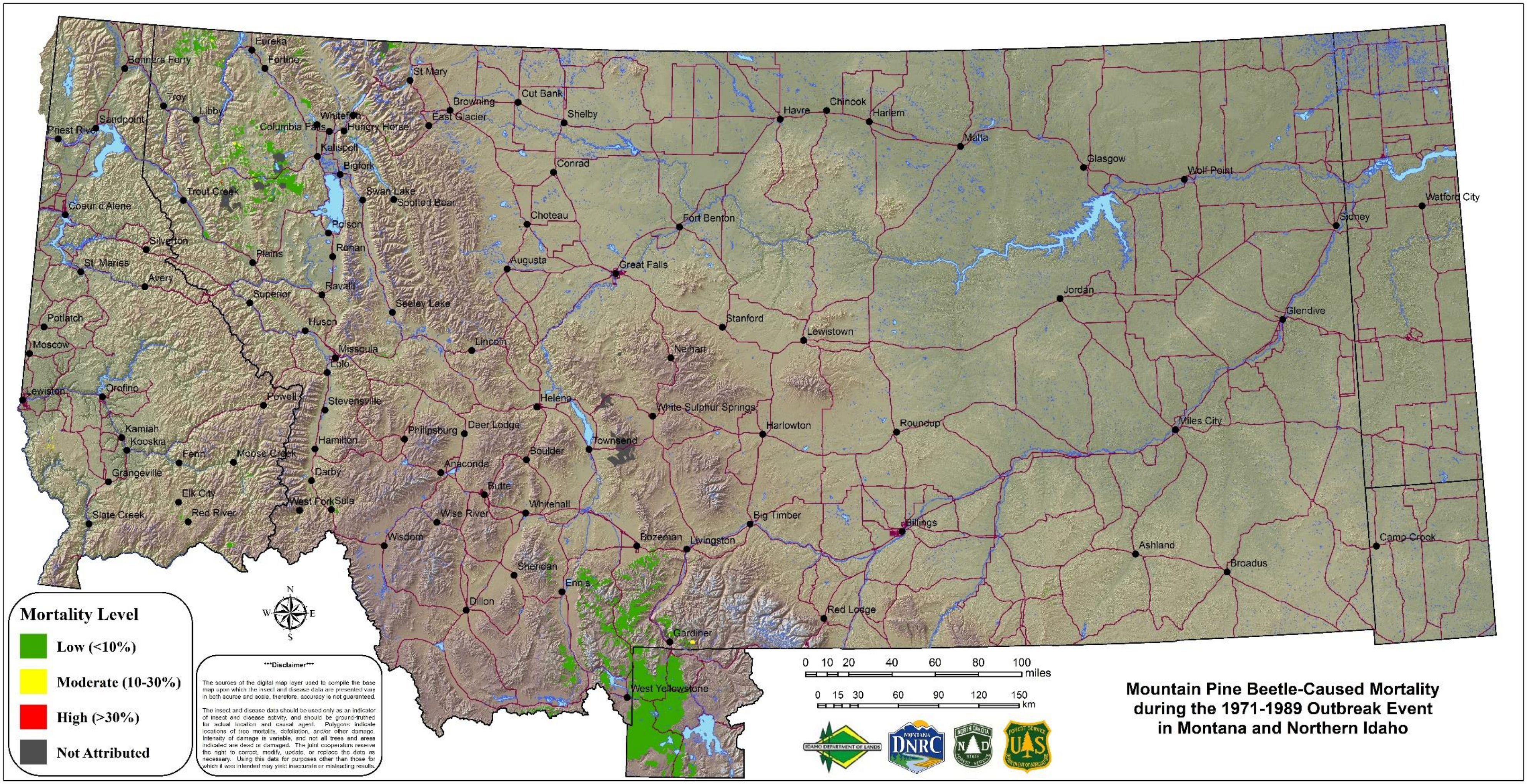
1983: Annual mountain pine beetle-caused mortality estimated by ADS


Mortality Level
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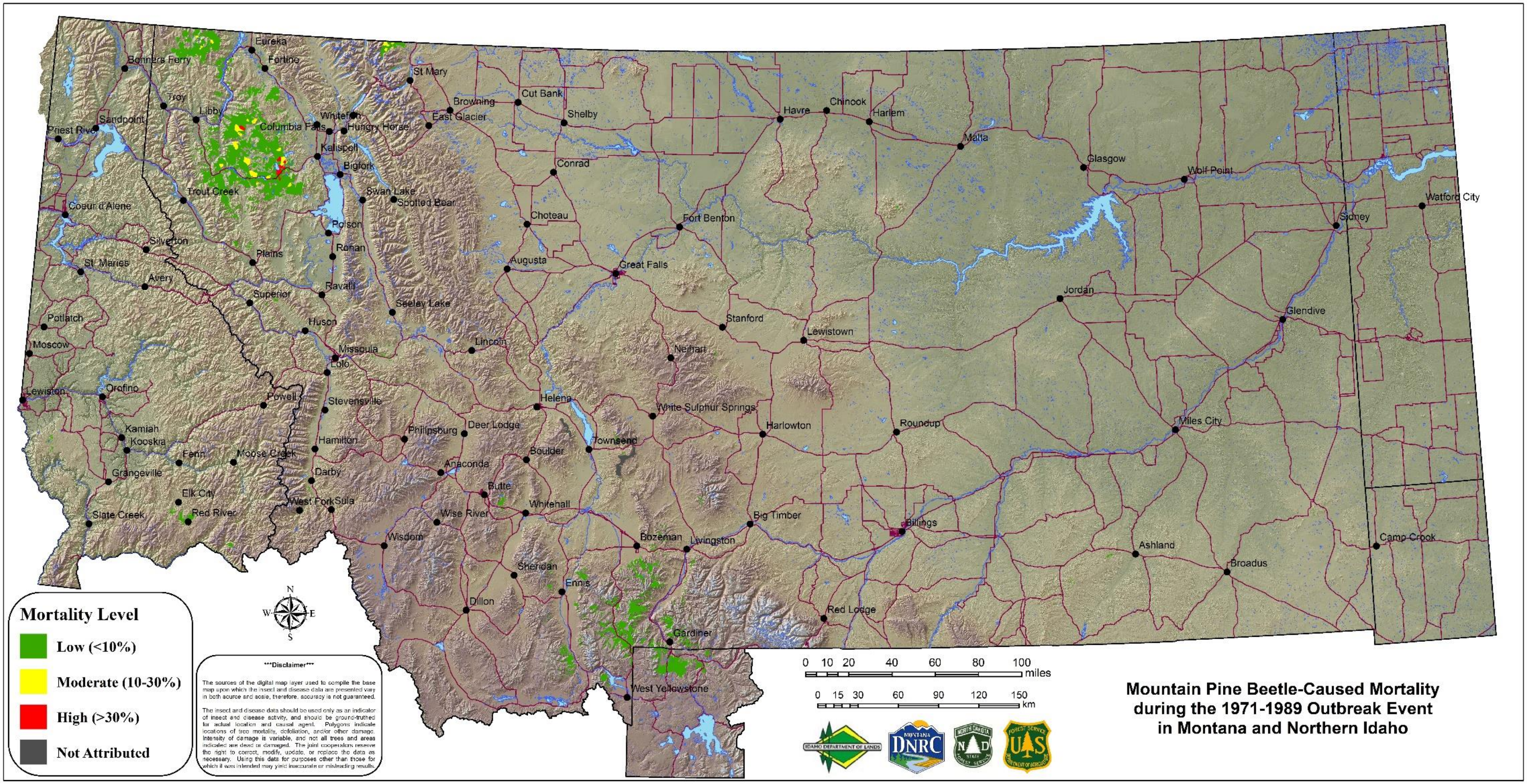
Mountain Pine Beetle-Caused Mortality during the 1971-1989 Outbreak Event in Montana and Northern Idaho

1984: Annual mountain pine beetle-caused mortality estimated by ADS


Mortality Level
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🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
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West Yellowstone
0 10 20 40 60 80 100 miles
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Mountain Pine Beetle-Caused Mortality
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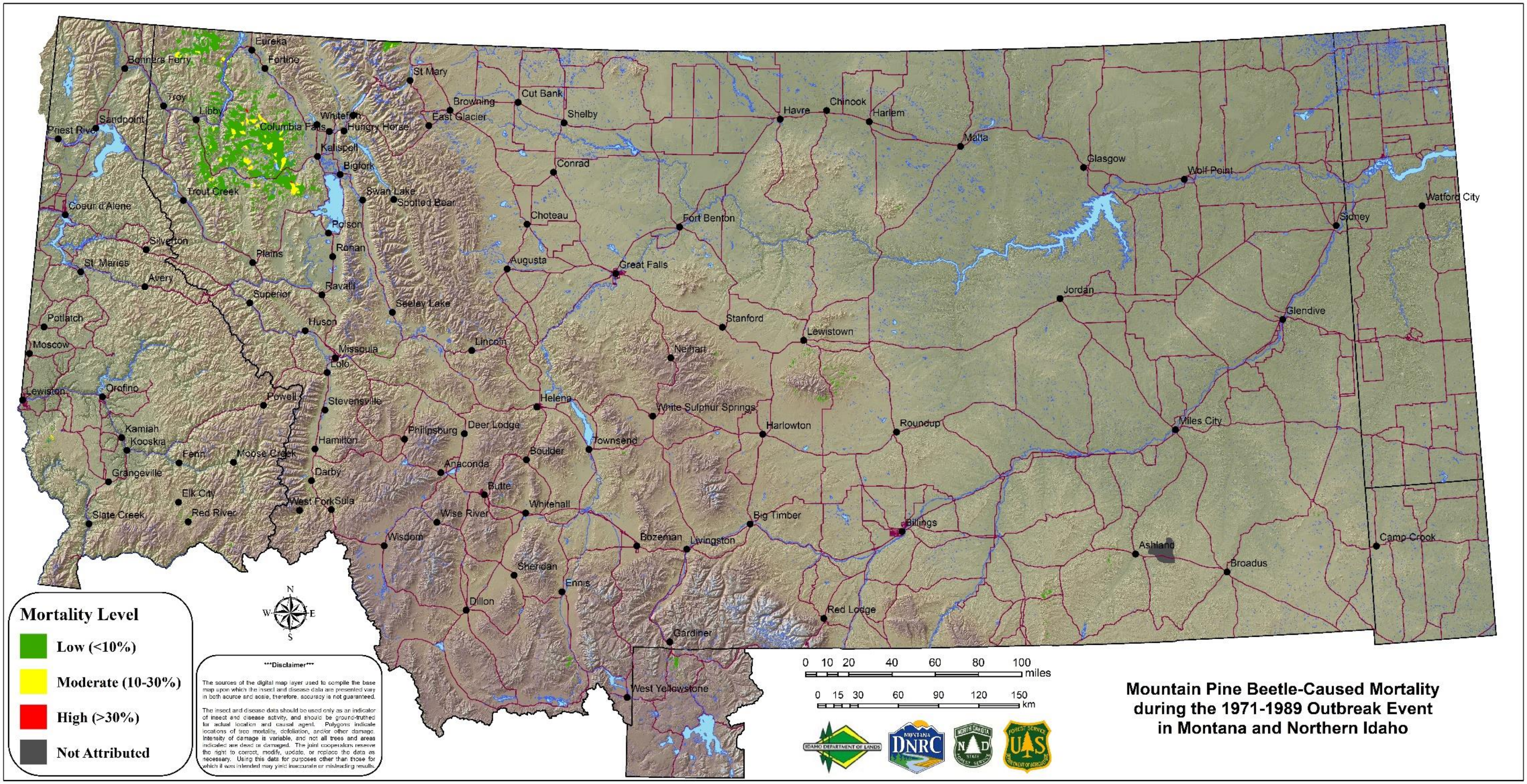
1985: Annual mountain pine beetle-caused mortality estimated by ADS


Mortality Level
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🟥 High (>30%)
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0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
Mountain Pine Beetle-Caused Mortality during the 1971-1989 Outbreak Event in Montana and Northern Idaho
Eureka
Bonners Ferry
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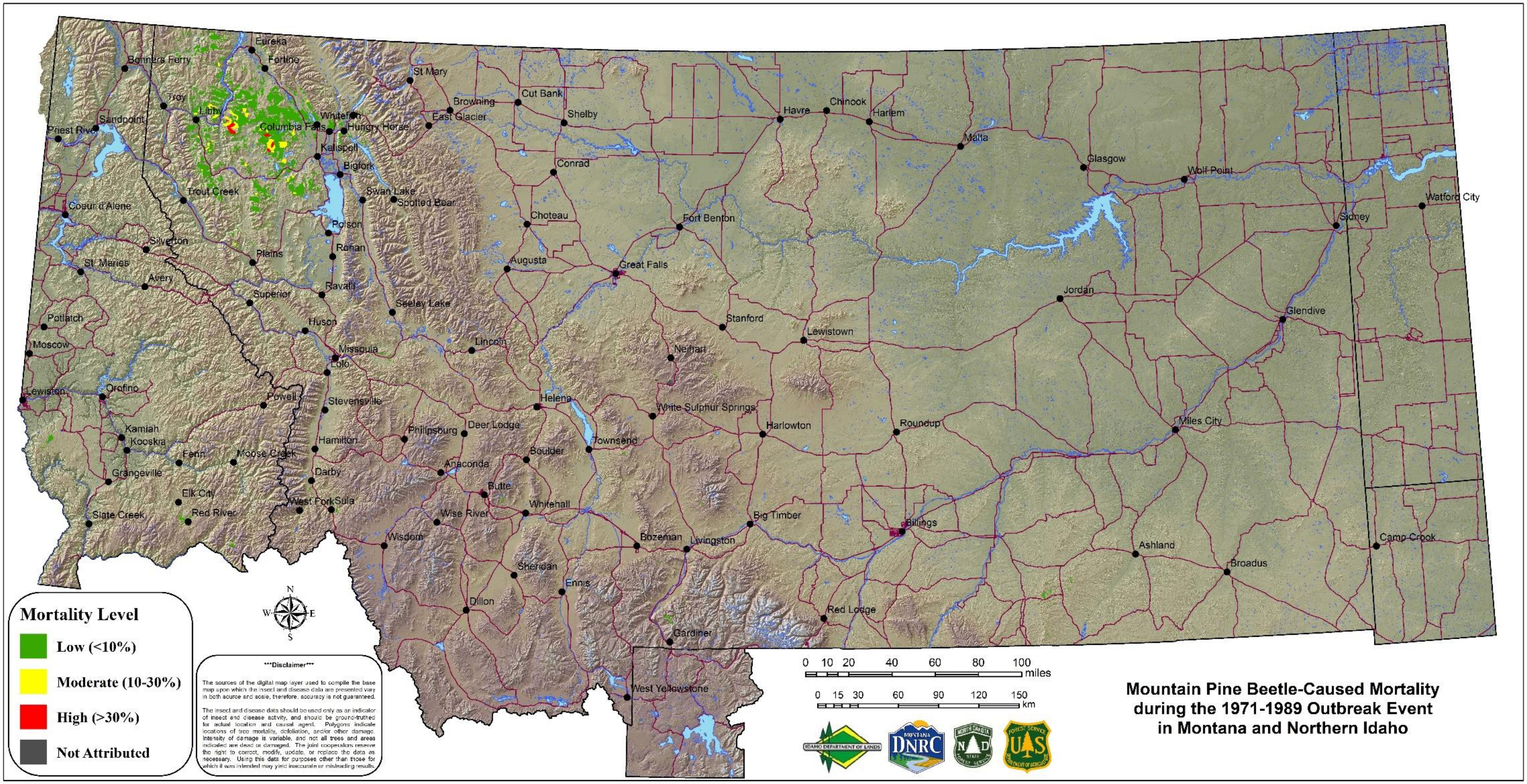
1986: Annual mountain pine beetle-caused mortality estimated by ADS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0 10 20 40 60 80 100 miles
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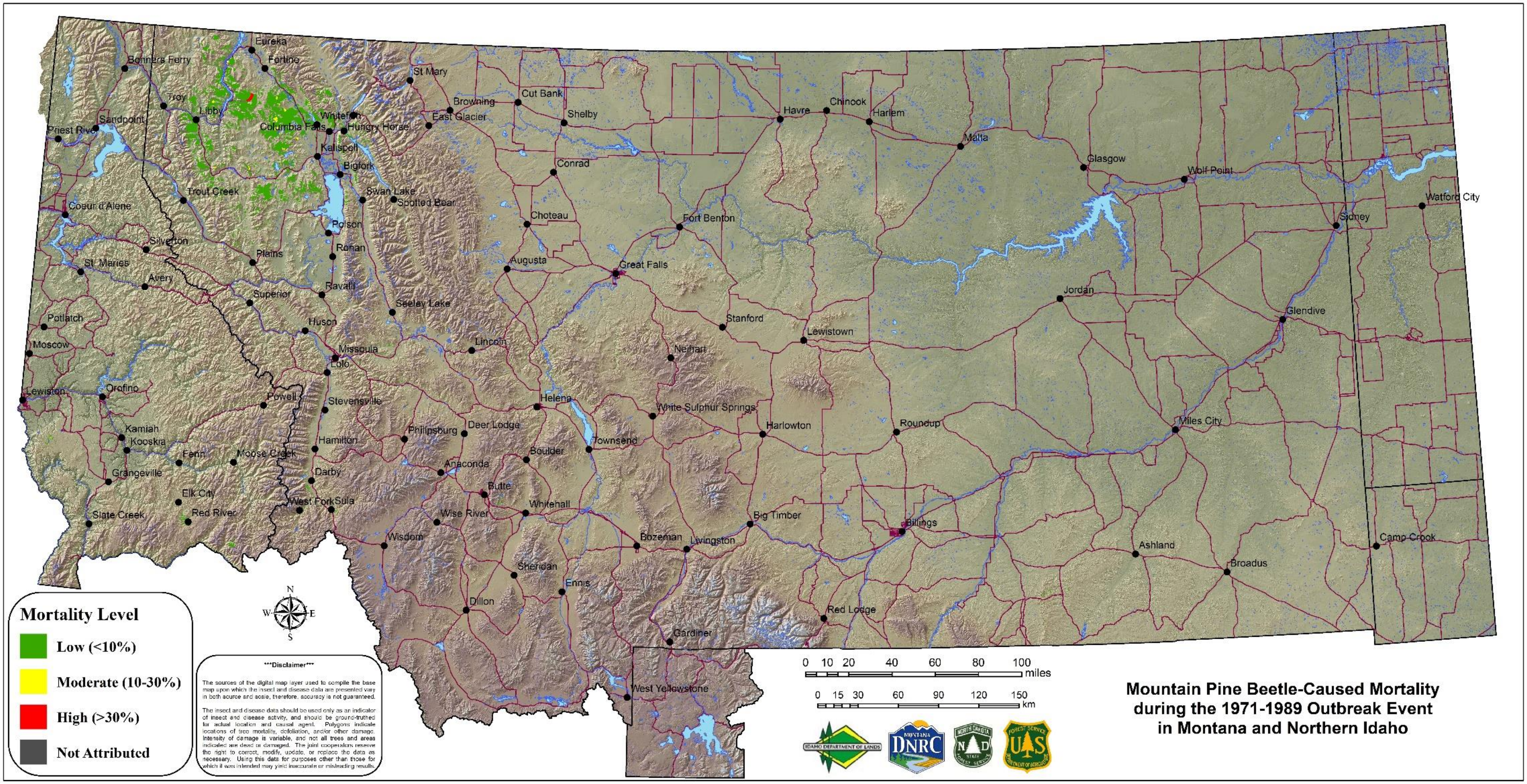
1987: Annual mountain pine beetle-caused mortality estimated by ADS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🟨 Moderate (10-30%)
🟥 High (>30%)
■ Not Attributed
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0 10 20 40 60 80 100 miles
0 15 30 60 90 120 150 km
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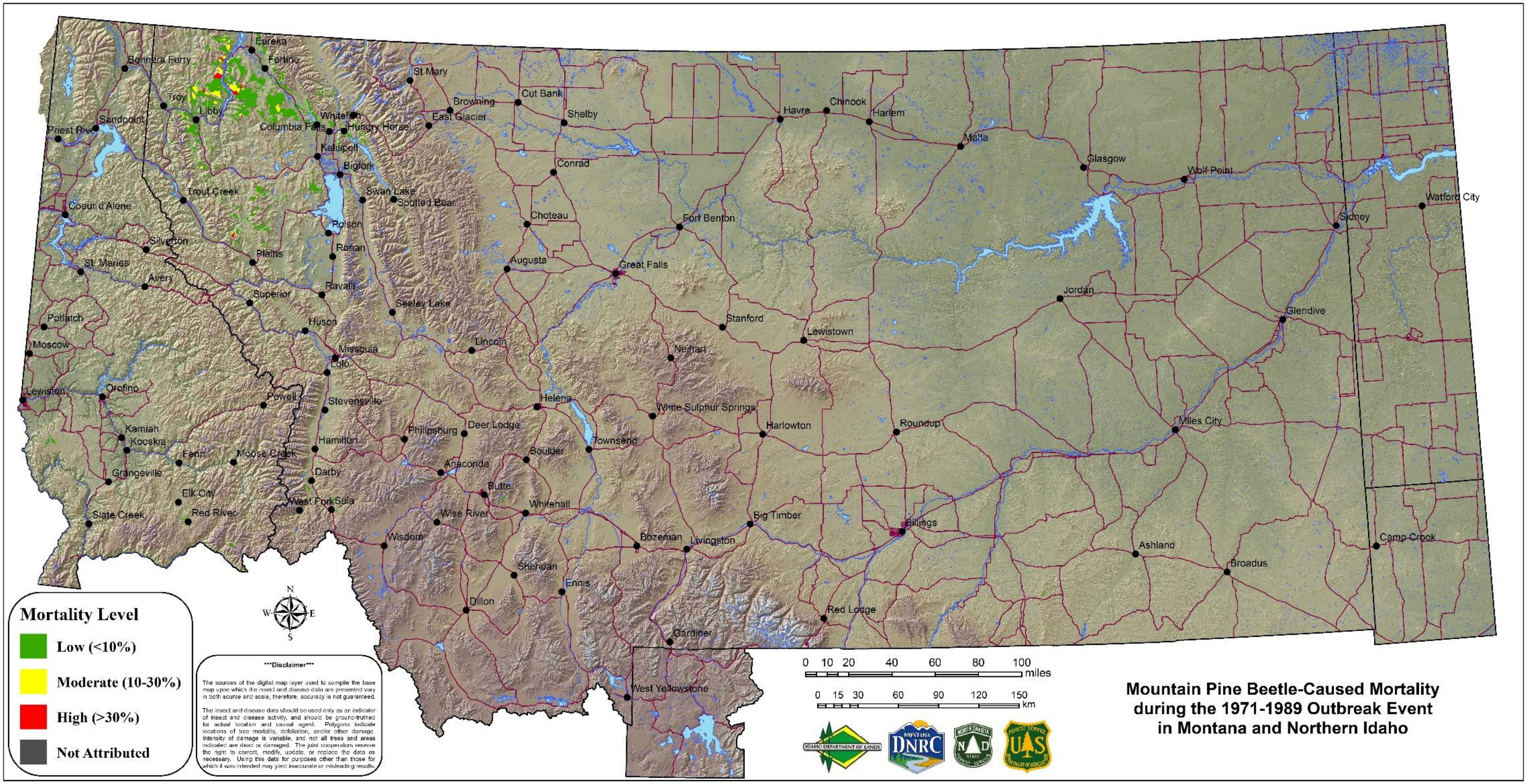
1988: Annual mountain pine beetle-caused mortality estimated by ADS


Mountain Pine Beetle-Caused Mortality
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🟨 Moderate (10-30%)
🟥 High (>30%)
⬛ Not Attributed
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0 15 30 60 90 120 150 km
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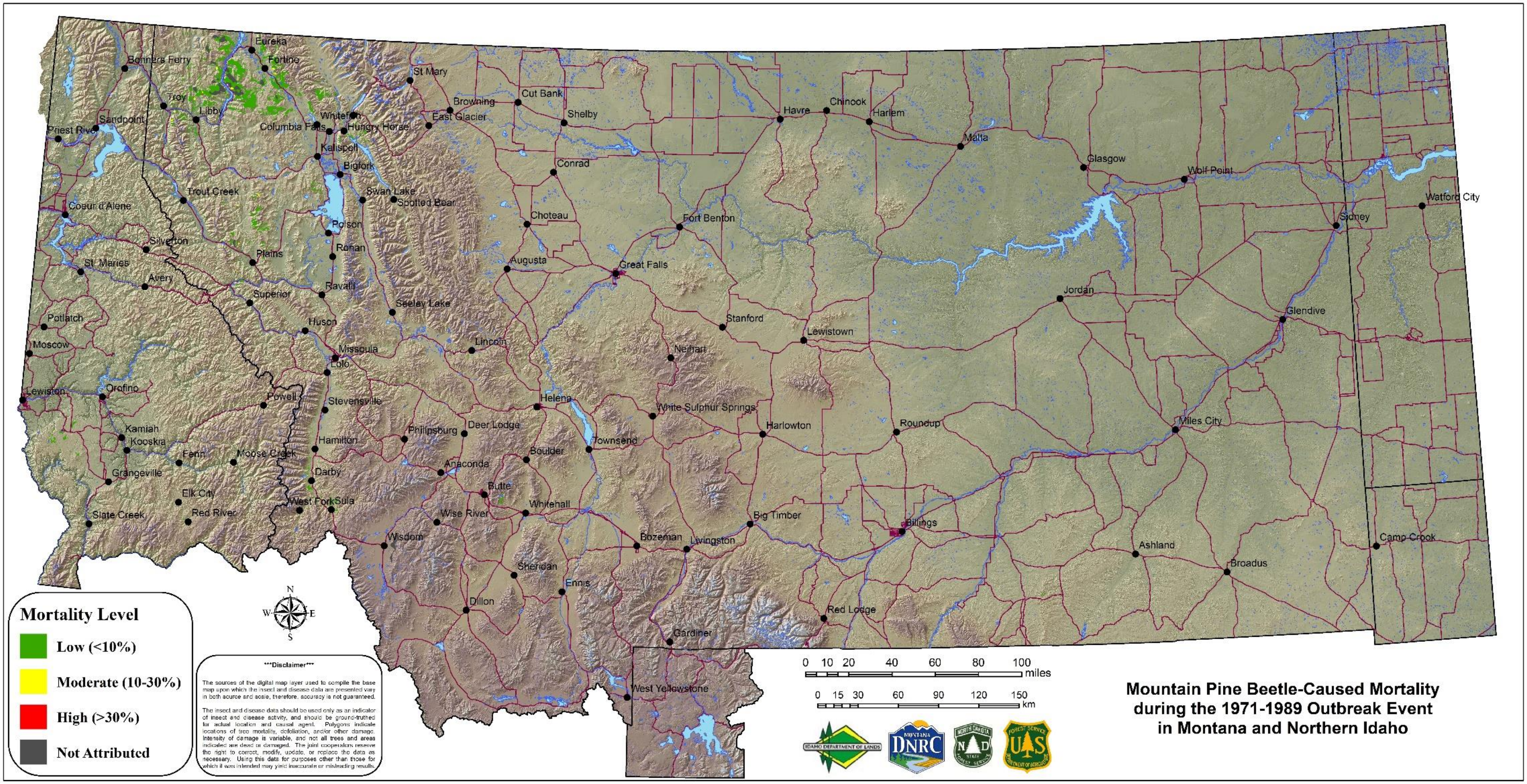
1989: Annual mountain pine beetle-caused mortality estimated by ADS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Swan Lake
Spotted Bear
Coeur d'Alene
Polson
Choteau
Fort Benton
Watford City
Sidney
Silverton
Ronan
Plains
St. Maries
Augusta
Great Falls
Avery
Ravalli
Superior
Jordan
Seeley Lake
Potlatch
Huson
Stanford
Glendive
Lewistown
Moscow
Lincoln
Missoula
Lolo
Neihart
Lewiston
Orofino
Powell
Stevensville
Helena
White Sulphur Springs
Kamiah
Kooskia
Philipsburg
Deer Lodge
Hamilton
Harlowton
Roundup
Miles City
Townsend
Fenn
Moose Creek
Boulder
Anaconda
Grangeville
Darby
Elk City
Butte
West Fork
Sula
Whitehall
Slate Creek
Red River
Wise River
Big Timber
Billings
Wisdom
Bozeman
Livingston
Camp Crook
Ashland
Sheridan
Broadus
Ennis
Dillon
Red Lodge
Gardiner
West Yellowstone

Disclaimer

The sources of the digital map layer used to compile the base map upon which the insect and disease data are presented vary in both source and scale, therefore, accuracy is not guaranteed.

The insect and disease data should be used only as an indicator of insect and disease activity, and should be ground-truthed for actual location and causal agent. Polygons indicate locations of tree mortality, defoliation, and/or other damage. Intensity of damage is variable, and not all trees and areas indicated are dead or damaged. The joint cooperators reserve the right to correct, modify, update, or replace the data as necessary. Using this data for purposes other than those for which it was intended may yield inaccurate or misleading results.

Mountain Pine Beetle-Caused Mortality
during the 1971-1989 Outbreak Event
in Montana and Northern Idaho